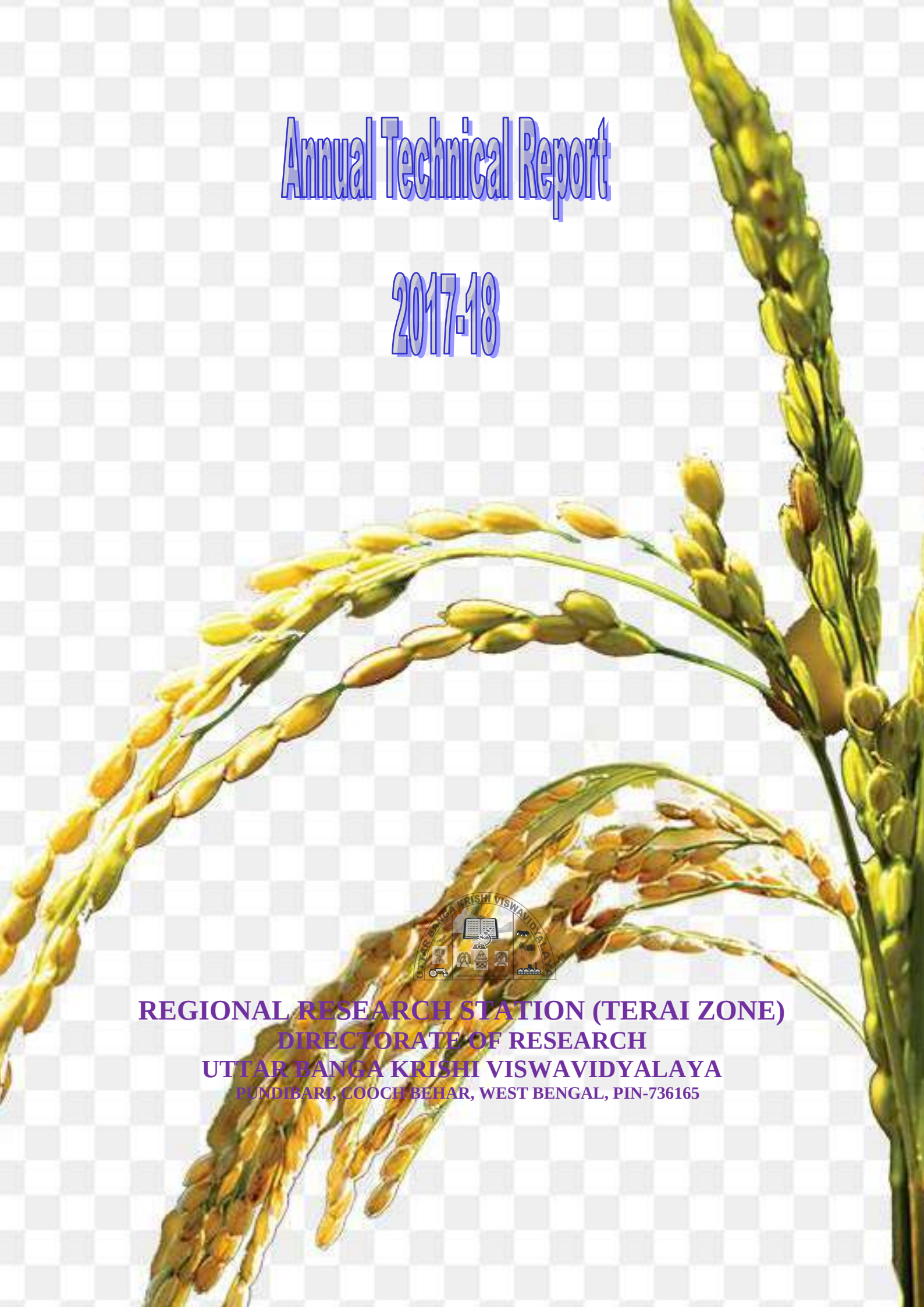
# Annual Technical Report

# 2017-18



## REGIONAL RESEARCH STATION (TERAI ZONE)

## DIRECTORATE OF RESEARCH

## UTTAR BANGA KRISHI VISWAVIDYALAYA

**PUNDIBARI, COOCH BEHAR, WEST BENGAL, PIN-736165**

# Contents

# Preface

*With an objective of catering the location specific research need of sub Himalayan plains of the State, the Regional Research Station for Terai Zone was established in 1978 under the then newly formed North Bengal Campus of Bidhan Chandra Krishi Viswavidyalaya (BCKV) at Pundibari, Cooch Behar. Subsequently blessed with human resource support from National Agricultural Research Project (NARP) in 1990, the research activity of the Station achieved a strategic boost through formulation of bench level study of the zone. The goal setting was done on the basis of identified rationales and the task was accomplished by dedicated participation of multi-disciplinary group of scientists each committed to his/her own field.*

*In 2001, the Station extended adequate support in formulation of new Directorate of Research of Uttar Banga Krishi Viswavidyalaya (UBKV) born out of bifurcation of BCKV and since then it became a constituent of the same. This also incurred some static change in scientists group through optional discontinuity of few seniors and subsequent refilling by fresher. Under the present era of UBKV, the station observes due responsibility to keep parity with the predecessors vis-a-vis setting new goals pertaining with existing agro ecological dynamics of the zone.*

*Based upon the research need of this area under consideration programmes are adopted and carried out accordingly on seasonal basis twice in a year i.e. Rabi and Kharif. Apart from half yearly project formulation session, Scientists meet regularly for technical discussion on progress of running programmes once in every month and all issuesrelated with same are covered duly.*

*The present Report comprises of results obtained out of programmes under taken at the Station for three consecutive crop seasons i.e. Pre Kharif , Kharif 2017and Rabi 2017-18.*

*Critical observations, suggestions on this report will be cordially accepted for further improvement of the same.*

*Prof. Ashutosh Sarkar*
**In-Charge, RRS (Terai Zone) Uttar Banga Krishi Viswavidyalaya Pundibari, Cooch Behar 736165**

## List of Kharif-2017-18 Programme under RRSTZ

| Sl. No. | Project Code | Title of the Programme | Associate Scientists |
|---|---|---|---|
| **Animal Science & Fishery** | | | |
| 1 | RRSTZ/Kharif/17-18/04 | Studies on the prevalence of the major vector borne diseases affecting cross breed cattle in Cooch Behar district, West Bengal | Dr. Nonigopal Shit<br>Dr. Dilip Kumar Hajra |
| 2 | RRSTZ/2017-2018/Kharif/05 | Improved induced breeding program on Asian magur through administration inducing hormone and different synthetic analogues. | Prof. Debapriya Sarkar and Dr. Nilanjana Chaudhuri |
| 3 | RRSTZ/2017-2018/Kharif/06 | Performance trial of different crops with fish under Integrated Farming System Research in the fish farm of RRS, Terai Zone | Prof. Debapriya Sarkar and Dr. Nilanjana Chaudhuri |
| **Crop Improvement** | | | |
| 4 | RRSTZ/2017-2018/Kharif/03 | Selection of mungbean genotypes for tolerance to water-logging under field condition | Dr. Rupsanatan Mandal |
| **Crop Production** | | | |
| 5 | RRSTZ/Kharif/17-18/02 | Project Title: Improved package of practices for major Agricultural and Horticultural crops in Terai Zone of West Bengal. | Dr. Parthendu Poddar, Dr. Suchand Datta, Dr. Partha Sarathi Patra |
| **Crop Protection** | | | |
| 6 | RRSTZ/Kharif/17-18/01 | Project Title: A Review on the Occurrence of Pests and Diseases of major crops and Their Management in Terai Region of West Bengal | Dr. Suprakash Pal, Dr. Nilanjana Choudhuri, Dr. Satyajit Hembram |

## ANIMAL SCIENCE AND FISHERIES

**Title of the Programme:** Studies on the prevalence of the major vector borne diseases affecting cross breed cattle in Cooch Behar district, West Bengal

**Project code:** RRSTZ/Kharif/17-18/04

**Associate Scientist/s:** Dr. Nonigopal Shit & Dr. Dilip Kumar Hajra

**Objectives:**

- ✓ The investigation of the prevalence of vector borne haemoprotozoan diseases in cross breed cattle population in Cooch Behar district

Figure 1: Blood collection at the peripheral circulation and thin smear preparation from the different areas of Cooch Behar district

**Methodology of the programme:**

- ✓ *Sample collection:*

- Blood collection (at least 5ml) was aseptically made from the jugular vein or peripheral circulation (ear vein) of the target animals in an anti-coagulant coated sterile sample collection vial labelled previously as required. Immediately after collection, sample was temporarily kept in the ice-pack insulated box and brought cautiously to the laboratory without hemolysis.

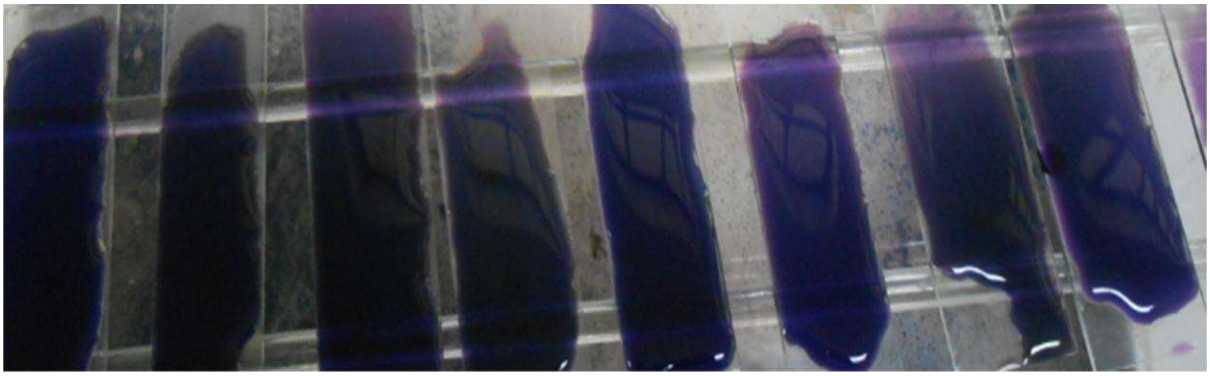
Figure 3: Microscopic examination (100X) of *haemoprotozoan* parasites of cross bred cattle in Cooch Behar district

✓ *Smear preparation and centrifugation:*

- A small drop of fresh blood was mounted over a dry and grease free slide and using another slide of smooth edge, a thin blood smear was made in triplicate. The rest blood was centrifuged following standard protocol (3000 rpm for 10min) for the serum extraction. The serum was emptied to the serum collection cryo-vials suitably labelled and stored at -18$^{o}$C for further biochemical study.

✓ *Staining and Microscopic examination:*

- Glass slides with thin blood smear were air dried and fixed with methanol (75%). Consequent to that glass slides were kept on the staining rack and the smear was stained with diluted Giemsa's stain (Himedia Pvt. Ltd) following to manufacture's instruction. The stain was allowed for 15min and finally washed under slow tap water till the stain is removed. The smear was air dried completely and each slide was examined under oil emersion microscope (100 x illuminations) and counted the total number of parasites from at least fifty fields of each slide.



**Staining of dry blood smear**

Figure 2: Giemsa's staining of dry blood smear at the laboratory, animal science unit for the prevalence study of *haemoprotozoan* parasites

**Results:**

✓ The study was focused to examine the occurrence of the *haemo-protozoan* parasites in the cross bred cattle under Cooch Behar district. Among the total 200 samples, only 28, 5, 13 and 2 samples were recorded positive for the Theileriosis, Babesiosis, Anaplasmosis and Trypanosomiasis respectively. On the percent prevalence basis, Theileriosis (*T. annulata*) revealed highest degree of prevalence (14%) and the least infection was counted for Trypanosomiasis (*T. evansi*).

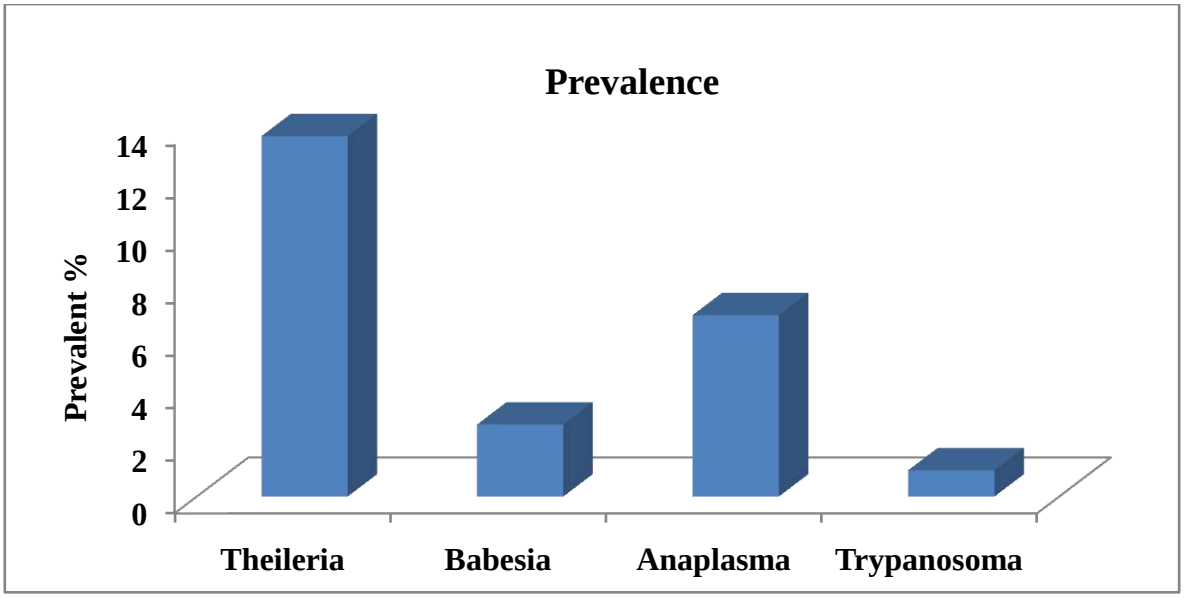



Figure 4: Prevalent percent of the *haemo-protozoan* parasites recorded in the cross bred cattle in Cooch Behar district

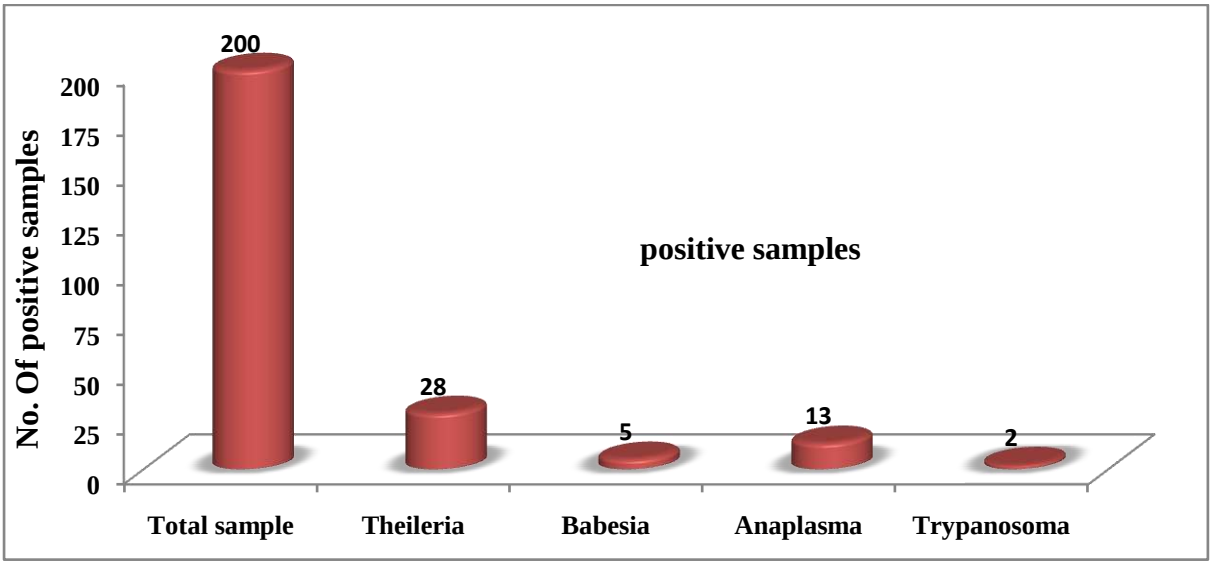



Figure 5: Positive samples of different *haemo-protozoan* parasites in the randomly collected blood of cross bred cattle in Cooch Behar district

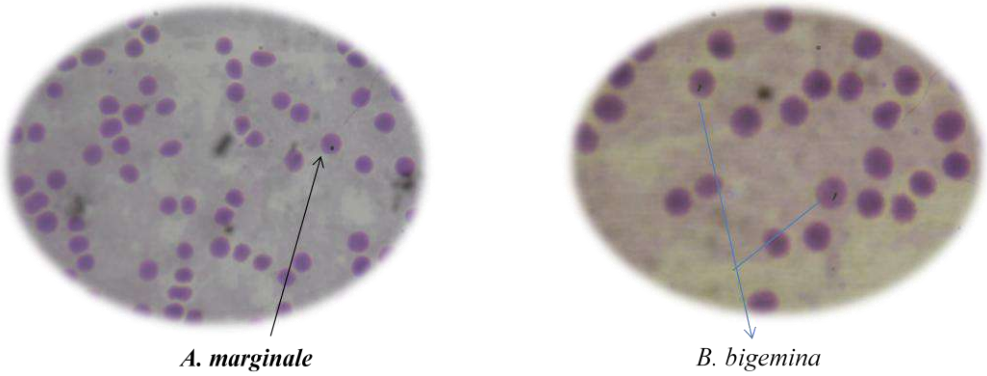



Figure 6: Identification of the intra-cellular *haemoprotozoan* parasites under oil emersion microscopic examination

- ✓ The questionnaire survey prior to this study demonstrated in spite of the proper management animals suffers from the chronic problems of anorexia, laboured breathing, gradual loss of production and susceptibility to diseases even in minor changes of climatic condition. The present findings could be invariably correlated with these facts and facets which are prevailed over the field condition. Biochemical analysis may correlate more precisely to reach at pin point diagnosis. Further study including DNA based molecular diagnosis of the antigen for those parasites will be more valuable for concrete year round recommendations

## ANIMAL SCIENCE AND FISHERIES

**Title of the Programme: Improved induced breeding program on Asian magur through administration inducing hormone and different synthetic analogues.**

**Project code:** RRSTZ/2017-2018/Kharif/05

**Associate Scientist/s:** Prof. Debapriya Sarkar and Dr. Nilanjana Chaudhuri

**Objectives:**

- ✓ Assessment on comparative efficacy of ALFA-FH (synthetic hormone) and pituitary extract (natural hormone) on stripping method of induced breeding in Asian magur.
- ✓ Comparison betweennumber of hatchlings produced from stripping (sacrifice) and non-sacrifice method of induced breeding.
- ✓ Interpretation on cost analysis for both ways.

### EXPERIMENTAL DESIGN

### Experiment No. 1.

**Title : C**omparative efficacy of ALFA-FH and pituitary extract on stripping method of induced breeding in *Clarius batrachus*.

### Methodology :

- Five sets (males : females = 2:1) of brood Asian magur each weighing 200-250g were separately injected with ALFA-FH and pituitary hormone @ 0.4 ml/100 g and 4mg/100g body wt of female respectively.
- Stripping method were followed for egg collection from females after 16 hrs
- Sperm fluid were collected through sacrificing the males
- Two males were used to fertilize eggs collected from one female
- Sticky fertilized eggs were kept in aluminium tray with medium water flow to get hatchlings within 24 hours (Fig.1)
- Hatchlings were fed after 72 hrs with artemia as recommended for 15 days and later on with egg custard or boiled rice and eggs to attain a length of 2 inches.

### Observations :

**Table 1. Summary table of Asian magur breeding with ALFA-FH and Pituitary extract**

| | ALFA-FH | PITUITARY EXTRACT |
|---|---|---|
| Av.wt of female (g) | 200 g | 200 g |
| Av.wt of male (g) | 250 g | 250 g |
| Dose in female | 0.4 ml/100gbw | 4 mg/ 100 g bw |
| Dose in male | 0.2 ml/fish | 2 mg / fish |
| Av. no of eggs released | 2650 nos/100g | 4500 nos/100g |
| No of hatchlings | 1000 nos/100g | 2500 nos/100g |

**Interpretation :**

Table 1 clearly indicated a better performance by pituitary extract as compared with ALFA-FH as inducing agent in stripping method. There was a better maturation and free flowing status of females injected with pituitary leading to more number of hatchling production from stripping method. Actually pituitary gland contains natural gonadotropic hormones (GTH) like FSH and LH which induces ovarian and testicular follicles to develop and to secrete steroids like oestrogen and progesterone from the gonads to initiate reproductive process. It is easily acceptable and adjustable by any fish being natural inducing agent whereas ALFA – FH being a synthetic analogue of Salmon GnRH is comparatively less acceptable and thereby elicit less reproductive response. Still the synthetic agents are used widely as it is ready to use and its quality is assured whereas availability and quality of pituitary gland is doubtful and complicated to prepare in suspension.

**Experiment No.2.**

**Title:** Production of hatchlings bynatural (non-sacrifice) induced breeding without sacrifice of maleusing ALFA-FH and pituitary extract as inducing agents.

**Methodology :**

Eleven experimental trials were set for induced breeding experiments by ALFA-FH and pituitary extract. For each experiment male and female ratio were 3:3 and the dose of administration of both inducing agents as well procedure followed were mentioned in the **Table 2**

| Trial No | Illustration of breeding method followed |
|---|---|
| T1 | ALFA-FH - Dose of injection @0.4ml/100g female and 0.15ml/100g male. Injected fish released into the 'glass aquaria (4'x1.5'x1.5') in the evening with constant aeration. |
| T2 | ALFA-FH –Dose same as above. Fish released into large cement vat (5'x3'x3') bearing soil bed and rooted grass to reflect an apparent natural pond situation and with aeration. |
| T3 | ALFA-FH – Dose same as above. Released into large cement tanks (5mx2.5mx1.5m) bearing soil bed and rooted grass and water hyacinth to reflect an apparent derelict pond situation and with no water flow. |
| T4 | ALFA-FH – Dose lowered @ 0.2ml /female and 0.1ml /male as initial installment for preparing and after 7 days again the same dose for breeding. Released into large cement tanks (5mx2.5mx1.5m) bearing soil bed and rooted grass only. |
| T5 | ALFA-FH – Dose lowered @ 0.2ml /female and 0.1ml /male Released in morning into the large cement tanks (5mx2.5mx1.5m) bearing soil bed and rooted grass to reflect an apparent natural derelict pond situation and with continuous moderate water flow. |
| T6 | ALFA-FH – Dose of injection @0.3ml/100g female and 0.15ml/100g male. Released into the small experimental pond with no artificial aeration. |
| T7 | PITUITARY-Dose of injection @15mg/250g female and 5mg/250g male. Released into large cement tanks (5mx2.5mx1.5m) bearing soil bed and |

| | |
|---|---|
| | rooted grass and water hyacinth to reflect an apparent derelict pond situation and with no water flow. |
| T8 | PITUITARY-Dose of injection @15mg/250g female and 5mg/250g male. Released into large cement tanks (5mx2.5mx1.5m) bearing soil bed and rooted grass and water hyacinth to reflect an apparent derelict pond situation and with continuous moderate water flow. |
| T9 | PITUITARY- Three different dose to three set of breeding pair @15mg, 10mg and 5mg /250g female and 5mg/250g male. Released into a deep earthen channel connected with another narrow channel located upward so as to provide scope for their upward migration for breeding. |
| T10 | PITUITARY-Dose of injection @15mg/250g female and 5mg/250g male. Released into the small experimental pond with no artificial aeration . |
| T11 | PITUITARY-Dose of injection @10mg/250g female and 5mg/250g male. Released into the channel excavated throughout the length of the rice field during the end of july,2017(during monsoon). |

**Interpretation** :

- ✓ Both ALFA-FH (synthetic analogues of gonadotropin) and pituitary extract (containing natural gonadotropin hormone) can induce spawning of asianmagur in cement tanks as well as earthen ponds provided there is sufficient water flow, either natural (as rain) or artificial, in the spawning ground.
- ✓ Dose of inducing hormone is a prime determining factor for fish breeding. Even dose of hormone used for stripping method had been proved to be very high and detrimental to those fish lying under non-stripping natural induced breeding as observed in case of T1 and T7. Therefore a low dose of hormone for natural induced breeding is alwayspreferred.
- ✓ Success of non-stripping induced breeding technique was found to be dependent on continuous water flow in the breeding ground as observed in T5 and T8. However ALFA-FH injected fish in pond during monsoon resulted in successful breeding (T6) though hatchling collection as well as harvest is very difficult in monsoon from the natural ground and it lead to a high rate of predatory attack on hatchlings by so many natural predators existing in the ponds.
- ✓ Injected fish released into the stagnant earthen ponds merely promote any induced spawning. Therefore, in stead of earthen ponds, creation of an apparent weed infested breeding ground with inundation is desirable.
- ✓ The non-sacrifice method of induced breeding (without stripping) is a very significant achievement from the standpoint of animal ethics . It is also very easy to perform and therefore easily adoptable by the stakeholders. However, the number of hatchling production is less in this method .
- ✓ Interpretation on production of hatchlings and sale price between sacrifice and non-sacrifice method clearly indicate more profit in case stripping method as the number of hatchling production is more and they can be sold in the early stage of their life as they remain indoor whereas it is very hard to collect the hatchlings produced from

natural induction occurred in the natural water bodies and they are prone to predatory attack as they stay there for a long time.

| | Fingerling produced / 400g female | Hatchling produced / 400 g female | Sale price |
|---|---|---|---|
| Sacrifice method | - | 10000 | 40,000 |
| Non-sacrifice method | 400 | - | 4,000 |

1. From the standpoint of economic return as well as farmers profit, the stripping method is more recommendable and from the conservation point of view non-stripping method is more preferred. It is therefore recommendable to adopt both the techniques in a rational way by the fish breeders.

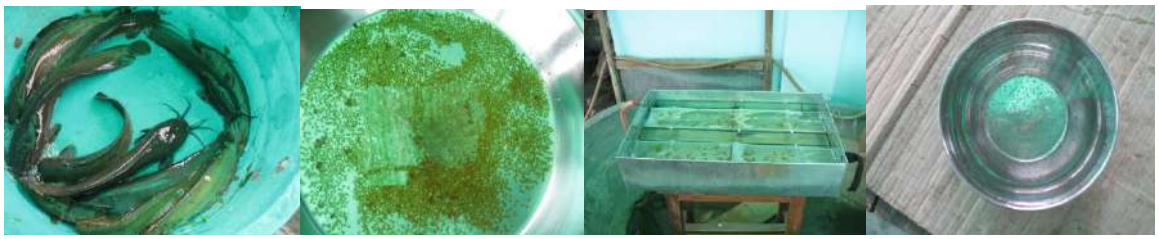


**Fig1.** Stages of stripping method in Asian magur induced breeding

Fig2. Release of injected fish in cement vat for induced breeding.

## ANIMAL SCIENCE AND FISHERIES

**Title of the Programme: Performance trial of different crops with fish under Integrated Farming System Research in the fish farm of RRS, Terai Zone**

**Project code:** RRSTZ/2017-2018/Kharif/06

**Associate Scientist/s:** Prof. Debapriya Sarkar and Dr. Nilanjana Chaudhuri

**Objectives:**

- ✓ To study the performance of Turmeric grown organically fish pond adjoining area
- ✓ To study the performance of Ginger grown in pond dyke and fish pond adjoining area
- ✓ To study the performance of Elephant foot yam in pond dyke
- ✓ To study the performance of plantation crops in pond dyke
- ✓ To study the performance of paddy-cum-fish culture in low lying pond adjoining areas
- ✓ To study the performance of water tolerant paddy variety in low lying pond adjoining areas with organic package of practice
- ✓ To study the performance of muga silkworm host plant (som) in medium land and the effect of nutrient supplementation and intercropping to make them grow fast in terai agro-climatic situation.
- ✓ To study the performance of fish in fish farm pond

**Materials:**

*Objective 1*

- ✓ Turmeric variety TCP 2 (Suranjana)
- ✓ Solid and liquid indigenous microbial culture,
- ✓ Handmade botanical insecticide (Agniastra)

*Objective 2*

- ✓ Ginger variety Local
- ✓ NPK at recommended dose and liquid indigenous microbial culture,
- ✓ Handmade botanical insecticide (Agniastra)

*Objective 3*

- ✓ Elephant foot yam variety Kavur
- ✓ NPK at recommended dose

*Objective 4*

- ✓ Areca nut and Coconut
- ✓ NPK at recommended dose

*Objective 5*

- ✓ The total area 225 $m^2$(paddy variety RajendraMashuri in 180 $m^2$ area, water channel 20 $m^2$ area (excluding 1m depth) for fish and dyke 25 m 2area.
- ✓ Solid and liquid indigenous microbial culture,
- ✓ Handmade botanical insecticide (Agniastra)

*Objective 6*

- ✓ Paddy variety RajendraMasuri, Nilanjana, MTU 1075 and Sabita
- ✓ Solid and liquid indigenous microbial culture,
- ✓ Han made botanical insecticide (Agniastra)

*Objective 7*

- ✓ Muga host plant Som (Machilusbombycina) as main crop.
- ✓ Turmeric, vegetable, spices, legume and oil seed crops as intercrops.
- ✓ Solid and liquid indigenous microbial culture.
- ✓ Hand made botanical insecticide (Agniastra)

*Objective 8*

- ✓ Lentil variety Moitree
- ✓ Solid and liquid indigenous microbial culture,
- ✓ Hand made botanical insecticide (Agniastra)
- ✓ NPK

**Methodology:**

*Objective 1*

- ✓ Turmericrhizome was planted during 1stweek of May in the 125$m^2$ plot.
- ✓ Solid indigenous microbial culture applied during field preparation.
- ✓ After that liquid indigenous microbial culture, was applied at fortnightly interval.
- ✓ Agniastra was applied as need based.
- ✓ The crop was harvested in February, 2018
- ✓ The observations of plant and yield parameters for conventional farming were taken from the field maintained under University farm.

*Objective 2*

- ✓ In the fish pond adjoining area (100 m2) Gingerrhizome was planted1st week of May, 2017 and in the same plot lentil was sown during 1st week of December, 2017.
- ✓ In the pond dyke only ginger was raised in 150 m2area.
- ✓ NPK at recommended dose applied during field preparation for ginger.
- ✓ After that liquid indigenous microbial culture, was applied at fortnightly interval.
- ✓ Agniastra was applied as need based.
- ✓ All the crop were harvested in March,2018

*Objective 3*

- ✓ Tuber of Elephant foot yam was sown during 1stweek of May in the 200 m2 area.
- ✓ Recommended agronomic practices were followed
- ✓ The crop was harvested in January,2018
- ✓ The average weight of each rhizome was 700 gm
- ✓ The yield was 7t/ha.

*Objective 4*

- ✓ 50 number of areca nut and 20 number of coconut seedlings were transplanted on and around the pond dyke during May, 2017.
- ✓ Recommended agronomic practices were followed

*Objective 5*

- ✓ The 21 days old seedling was transplanted during2nd fortnight of July, 2017
- ✓ Solid indigenous microbial culture during land preparation and after that liquid at fortnight interval
- ✓ The botanical insecticide (Agniastra) was applied as per need.
- ✓ Fish were released into the paddy field after 15 days of rice transplantation. Asian magur hatchlings (50 numbers and 20 days old) and freshwater prawn juveniles (100 numbers and 45 days old) were released in first phase. IMC fries name namely Rohu and Mrigel (1 kg and 30 days old) were released in the second phase.
- ✓ Growth of fish was checked monthly by netting.
- ✓ The crop was harvested in November, 2017

*Objective 6*

- ✓ Paddy variety namely RajendraMashuri, MTU 1075, Sabita and Nilanjana were raised in the plot size of 180 sq.m, 70 sq.m., 250 sq.m. and 110 sq.m. respectively
- ✓ 21 days old seedlings were transplanted by 1st fortnight of August
- ✓ Solid indigenous microbial culture applied during field preparation.
- ✓ After that liquid indigenous microbial culture, was applied at fortnightly interval.
- ✓ Agniastra was applied as need based.
- ✓ The crop was harvested in November-December,2017
- ✓ The observations of plant and yield parameters for conventional farming were taken from the field maintained under University farm.

*Objective 7*

- ✓ Muga host plant (100 numbers) was planted in 3mx3m in the medium land during 3rd week of September, 2017.
- ✓ The plants were transplanted in two parts, in one part of 250 m2 area the turmeric germplasm TCP 70 was planted during 1st week of May
- ✓ In the other part of 470 m2 area different vegetable, legume and oil seed crops was sown/transplanted during 2ndweek of December, 2017.
- ✓ Solid indigenous microbial culture applied during field preparation.
- ✓ After that liquid indigenous microbial culture, was applied at fortnightly interval.
- ✓ Agniastra was applied as need based.
- ✓ The turmeric was harvested in February,2018, vegetable, spices, legumes and oilseed crops were harvested in 1st week of April
- ✓ The observations of plant and yield parameters of turmeric for conventional farming were taken from the field maintained under University farm.

*Objective 8*

- ✓ Lentil and maize were sown duringlast week of December, 2017

## ANIMAL SCIENCE AND FISHERIES

- ✓ Both the crops were raised organically in 130 m2 plot and by conventional farming in 100 m2 area.
- ✓ Solid indigenous microbial culture applied during field preparation.
- ✓ After that liquid indigenous microbial culture, was applied at fortnightly interval.
- ✓ Agniastra was applied as need based.
- ✓ In conventional farming normal agronomic practices were followed
- ✓ The crop was harvested in March and May,2018

**Results:**

*Objective 1*

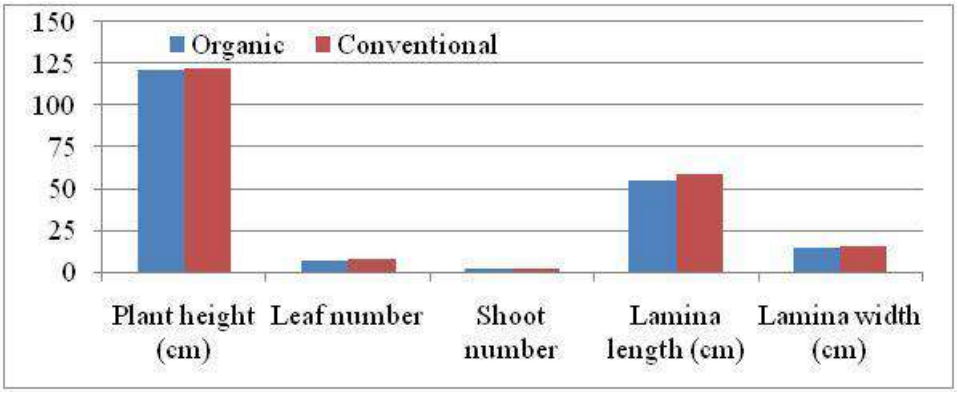



**Figure 1: Plant parameters of turmeric (variety Suranjana) raised in two different farming system**

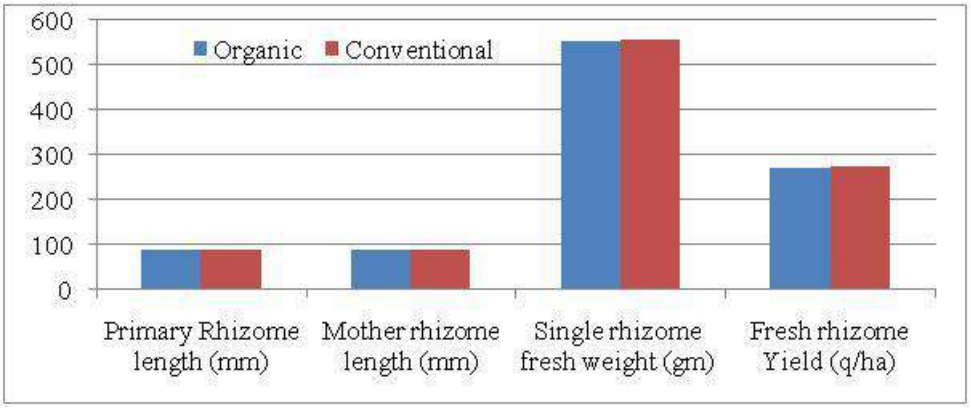



**Figure2: Yield attributing parameters of turmeric (variety Suranjana) raised in two different farming system**

## ANIMAL SCIENCE AND FISHERIES

*Objective 2*

**Table 1: Plant and yield attributing parameters of ginger (variety local)**

| Plant height (cm) | Shootnumber | Lamina length (cm) | Lamina width (cm) | Single rhizome fresh weight (gm) |
|---|---|---|---|---|
| 61.23 | 23.25 | 19.45 | 1.98 | 500 |

**Table 2: Comparative account of yield in two types of land situation**

| **Area** | **Crop** | **Yield t/ha** |
|---|---|---|
| Pond dyke | Ginger | 2.235 |
| Medium land adjacent to fish pond | Ginger | 2.558 |
| | Lentil | 1.50 |

*Objective 5*

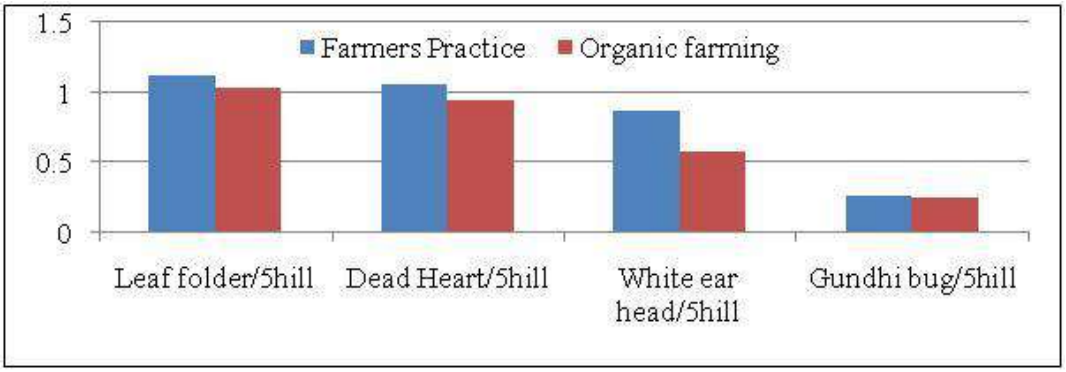



**Figure 3: Pest population infesting paddy in Kharif 2017**

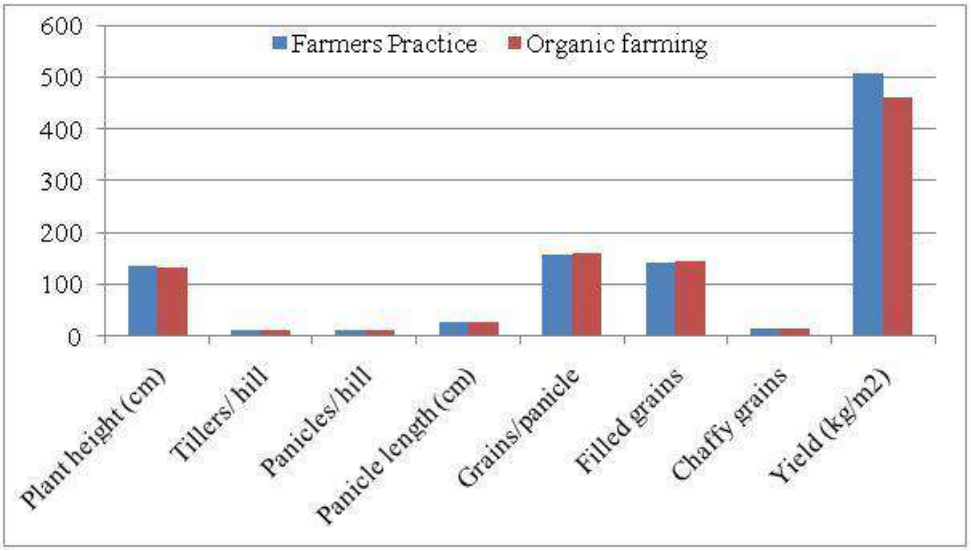



**Figure 4: Influence of cultivation practices on plant parameters of paddy at maturity**

## ANIMAL SCIENCE AND FISHERIES

### Table 3: Growth performance of fish in paddy field

| Parameters * | Fish Species | | | |
|---|---|---|---|---|
| | Rohu | Mrigel | Asian Magur | Prawn |
| Av Initial length (cm) in Aug | 2.5 | 2.2 | 2.0 | 1.5 |
| Av Initial weight (g) in Aug | 1.8 | 1.9 | 1.3 | 0.15 |
| Av length (cm) in Sep | 8.4 | 8.7 | - | 1.8 |
| Av weight(g) in Sep | 8.0 | 8.9 | - | 0.6 |
| Av length (cm) in Oct | 10.2 | 12.2 | - | 2.8 |
| Av weight(g) in Oct | 37 | 49 | - | 4 |
| Av final length (cm) in Nov | 11 | 14 | 14 | 6 |
| Av final weight(g) in Nov | 55 | 65 | 20 | 10 |
| Fish released | 0.5 kg | 0.5 kg | 50 nos | 100 nos |
| Fish production | 2.0 kg | 3.0 kg | 10 nos | 22 nos |
| Control weight (individual)(g) | 35 | 40 | 35 | 30 |

*No of sample taken to calculate average data is 4

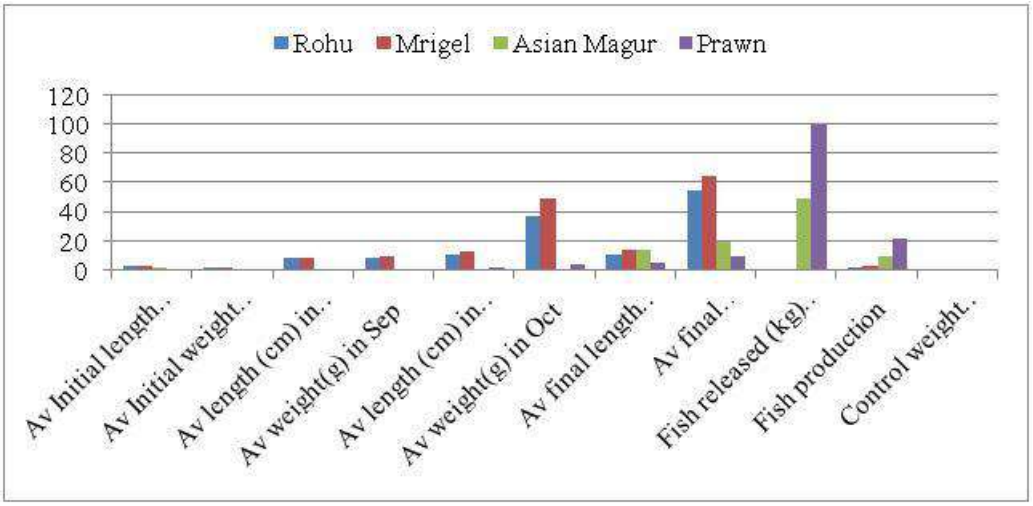



**Figure 5: Growth performance of fish**

*Objective 6*

**Table 3: Pest population infesting paddy varieties raise organically in Kharif 2017**

| Insect-pest populations | RajendraMashuri | | MTU 1075 | | Nilanjana | | Sabita | |
|---|---|---|---|---|---|---|---|---|
| | FP | OC | FP | OC | FP | OC | FP | **OC** |
| Leaf folder/5hill | 1.12 | 1.03 | 1.02 | 1.01 | 1.56 | 1.00 | 1.38 | 1.02 |
| Dead Heart/5hill | 1.06 | 0.95 | 1.00 | 0.85 | 1.23 | 1.11 | 1.14 | 1.02 |
| White ear head/5hill | 0.87 | 0.58 | 0.21 | 0.11 | 1.02 | 0.97 | 1.05 | 1.02 |
| Gundhibug/5hill | 0.27 | 0.25 | 0.21 | 0.14 | 0.32 | 0.21 | 0.37 | 0.30 |

FP= Farmers Practice; OC= Organic Cultivation

**Table 4: Influence of cultivation practices on plant parameters of paddy varieties at maturity**

## ANIMAL SCIENCE AND FISHERIES

| Plant Parameters | RajendraMashuri | | MTU 1075 | | Nilanjana | | Sabita | |
|---|---|---|---|---|---|---|---|---|
| | **FP** | **OC** | **FP** | **OC** | **FP** | **OC** | **FP** | **OC** |
| Plant height (cm) | 135.65 | 133.20 | 125.88 | 123.75 | 145.69 | 142.65 | 173.74 | 171.69 |
| Tillers/hill | 13.12 | 11.32 | 14.10 | 13.05 | 13.24 | 12.15 | 14.33 | 12.85 |
| Panicles/hill | 12.89 | 11.04 | 13.85 | 12.50 | 13.00 | 12.02 | 14.00 | 12.35 |
| Panicle length (cm) | 27.45 | 28.04 | 23.77 | 24.05 | 21.21 | 22.00 | 23.57 | 24.18 |
| Grains/panicle | 158.65 | 159.33 | 273.67 | 277.69 | 158.26 | 161.00 | 157.24 | 163.02 |
| Filled grains | 141.80 | 144.81 | 240.67 | 249.02 | 138.25 | 144.33 | 137.12 | 141.67 |
| Chaffy grains | 16.85 | 14.52 | 33.00 | 28.67 | 20.01 | 16.67 | 20.12 | 21.35 |
| Yield (kg $m^{-2}$) | 507.2 | 459.7 | 502.5 | 282.3 | 463.4 | 457.5 | 412.6 | 410.2 |

*Objective 7*

**Table 5: Plant parameters of turmeric (germplasm TCP 70) raised in som plantation**

| Farming practice | Plant height (cm) | Leaf number | Shoot number | Lamina length (cm) | Lamina width (cm) |
|---|---|---|---|---|---|
| Organic | 119.23 | 8.4 | 2.8 | 57.5 | 14.95 |
| Conventional | 124.32 | 9.2 | 3.2 | 61.8 | 16.25 |

**Table 6: Yield and yield attributing parameters of turmeric (germplasm TCP 70) raised in som plantation**

| Farming practice | Primary Rhizome Length (cm) | Mother rhizome length (cm) | Single rhizome fresh weight (gm) | Fresh rhizome Yield (t/ha) |
|---|---|---|---|---|
| Organic | 7.56 | 7.78 | 385.23 | 19.86 |
| Conventional | 8.00 | 7.89 | 388.25 | 20.56 |

**Table 7: Yield Performance of different crops in som plantation**

| Crop | Yield (t/ha) |
|---|---|
| Cabbage | 11.82 |
| Tomato | 30.15 |
| Carrot | 12.35 |
| Chilli | 16.56 |
| Pea | 9.32 |
| Lentil | 1.54 |
| Garlic | 1.85 |

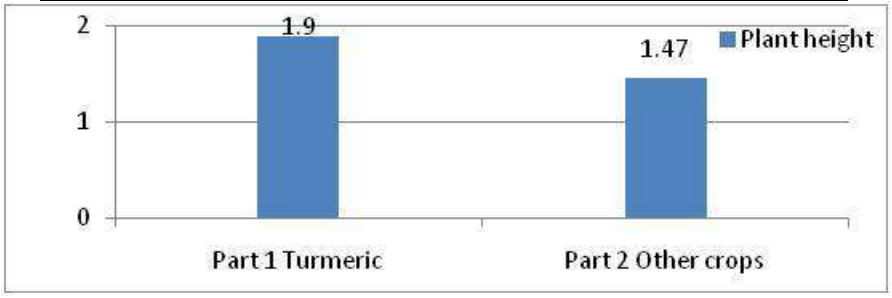



**Figure 6 : Performance of som plants**

**ANIMAL SCIENCE AND FISHERIES**

*Objective 8*

**Table 8: Performance of Lentil variety Moitree WBL77in two different farming system**

| Farming practice | Aphids /leaf | Yield gm plant$^{-1}$ | Yield t ha$^{-1}$ |
|---|---|---|---|
| Organic | 0.47 | 82.29 | 1.626 |
| Conventional | 0.68 | 78.83 | 1.616 |

**Table 8: Performance of Maize variety: DKC9081in two different farming system**

| Farming practice | Aphids Leaf $^{-1}$ | Leaf roller (folded leaves) Plant$^{-1}$ | Single Cob weight (gm) | Yield t ha$^{-1}$(fresh weight) |
|---|---|---|---|---|
| Organic | 0.50 | 0.047 | 248.35 | 4.09 |
| Conventional | 0.98 | 0.090 | 483.40 | 14.01 |

**Findings:**

*Objective 1*

- ✓ Plant and yield attributing parameters of Suranjanawere higher in conventional farming than the organic one but the difference was non-significant.
- ✓ Yield of TCP 70 was less than Suranjana. It was fade in colour and fresh weight of single rhizome was also lesser (388 g).

*Objective 2*

- ✓ Plant growth as well as rhizome growth is moderate.
- ✓ Ginger intercropped with lentil provided higher return as compared to sole crop.

*Objective 3*

- ✓ The average weight of each rhizome was 700 gm
- ✓ The yield was 7t/ha.

*Objective 4*

- ✓ Crops are growing satisfactorily in the loam soil whereas those in the sandy soil are a bit slow in their growth.

*Objective 5*

- ✓ The insect pest populations (leaf folder, yellow stem borer and gundhi bug) were observed more in the farmers practice than organically managed experimental plot.
- ✓ Plant height was comparatively higher in farmers' practice.

- ✓ Number of tillers/hill, panicles/hill, panicle length and grains/panicle were relatively more in organic farming over conventional farming.
- ✓ The yield was slightly lower in organic farming than conventional one.
- ✓ Growth of rohu and mrigel in the paddy field as well as water channel is optimum. However it is expected to enhance several manifolds with the increase in area under paddy-cum-fish cultivation and increase in water area and depth holding the fish throughout the culture period.
- ✓ Though the growth record of asianmagur is satisfactory but number harvested is really frustrating which is because of their escaping nature and its needs further protection across the dyke area of the land using strong and high nets so as to control escaping of fish.
- ✓ Performance of freshwater prawn juvenile in paddy field is not so satisfactory as in pond they grow much bigger where a separate care for their feeding is adopted. In the paddy field cannibalistic behaviour of prawn resulted in reduction in their number. At the same time, lack of sufficient food could not result in the optimum yield.

*Objective 6*

- ✓ The important insect-pests infesting paddy were stem borer, leaf folder and gundhi bug. The population was maximum in the field in conventional than organic farming.
- ✓ Plant and yield attributing parameters were comparatively higher in farmers' practice than organic cultivation.
- ✓ Yield performance followed an order of RajendraMashuri>Nilanjana>Sabita>MTU 1075

*Objective 7*

- ✓ The som plantintercropped with turmeric as well as different vegetables, legumes and oil seed crop attained the height of 1.90ft and 1.47ft respectively at 7 months after transplanting.
- ✓ Plant and yield attributing parameters of turmeric were slightly higher in conventional farming than the organic one but the difference was non-significant.

*Objective 8*

- ✓ Pest population of lentil and maize was observed lower in organically managed plots.
- ✓ The yield attributing parameters of lentil were higher in organic farming than the conventional one.
- ✓ The yield attributing parameters of maize were higher in conventionalfarming than the organic one.

**Future Scope:**

*Objective 1*

- ✓ There lies a huge scope to explore optimum growth and yield of this crop through continuous organic soil management applications

*Objective 2*

- ✓ There lies a huge scope to explore optimum growth and yield of this crop through organic soil management applications

*Objective 3*

- ✓ The average weight of each rhizome was 700 gm
- ✓ The yield was 7t/ha.

*Objective 4*

- ✓ There is ample scope of production as well income from this crop cultivated in pond dyke with improvement of soil quality in coming 2-3 years through optimum organic management practice.

*Objective 5*

- ✓ This technology can be adopted in thelow lying areas of teraizone having sandy loam soil and also in some other localities having less frequent ponds to obtain high paddy as well as fish yield from the paddy-cum-fish culture plots.

*Objective 6*

- ✓ Identification of more number of water tolerant variety of paddy for execution of paddy-cum-fish culture with organic culture practice in the low lying areas for better profit and sustainability.

*Objective 7*

- ✓ Improved growth will lead the plants to reach an optimum height required for muga silkworm rearing within shortest possible time and the lean period can be exploited by the farmer through income from the intercropped vegetables and spices.

**Recommendation**

*Objective 1*

- ✓ The yield of turmeric is almost same in both the farming system which suggests bright prospects of adoption of organic farming system for turmeric cultivation in this region.
- ✓ Turmeric has been proved to be one of the most optimally growing horticultural crops in the fish pond adjoining areas of terai zone bearing sandy soil with the help of minimum input and labour cost.

*Objective 2*

- ✓ The potential scope of ginger recommends its incorporation in the IFS system as a valuable spice crop.
- ✓ The quality improvement of sandy soil of pond dyke is essential to make the farming system more remunerative.

*Objective 3*

- ✓ The yield is not satisfactory this year as the crop was grown in the dyke containing highly sandy soil and it needs more attention for soil texture improvement in terms of nutrient supplement to the crop bearing plots.

*Objective 4*

- ✓ Proper growth of the plants in coming 5-6 years will make the IFS unit economically strong.

*Objective 5*

- ✓ Recommendation can be done after continuous conduction of the same experiment for 2 years in at least 1 acre plot.

*Objective 6*

- ✓ The result suggests bright prospects of adoption of sustainable organic farming system for paddy–cum –fish cultivation in terai region. Components of solid indigenous microbial culture and agniastra are mostly domestic and easily available and cheaper in price that will augment the technology adoption by the stakeholders.

*Objective 7*

- ✓ The gestation period of muga host plant is 4-5 years and to minimize the period, the option of intercropping in the inter spaces of som plants can be a better option.

## CROP IMPROVEMENT

***Project Title: Selection of mungbean genotypes for tolerance to water-logging under field condition***

**Project code:** RRSTZ/2017-2018/Kharif/03

**Associate Scientist/s:** Dr. Rupsanatan Mandal

**Objectives:**

- ✓ Identification of flood tolerance genotypes suitable for Terai Zone, West Bengal

**Materials:**

- ✓ . Ten mungbean genotypes viz. Samrat, Sonali, Sukumar, Panna, Birerswar, Selection -1, Selection-2, TC-39487, TC-39499, and TC-39544 were tested under this study.

**Methodology**:

- ✓ The experiment was conducted in the field of the Regional Research Station, Terai Zone, Uttar Banga Krishi Viswavidyalaya, Pundibari, Coochbehar during June, 2017 to August, 2017.
- ✓ The genotypes were flooded with 3-5 cm of standing water for 7 days (96 hours) at 25 days after emergence (DAE), 35 days after emergence and 45 days after emergence.
- ✓ The experiment was laid out in a split-plot design with three replications.
- ✓ Flooding treatments were placed in the main-plots and mungbean genotypes were in the subplots.
- ✓ The size of each main plot was 8m x 2m =16 m2 and the size of each subplot was (2m x 1.5m).
- ✓ Drain in between two main plots was 1.5 m so that flooded water cannot soak to the neighboring experimental plots.
- ✓ Each sub-plot had 5 rows of mungbean genotype with a spacing of 30 cm x 10 cm.
- ✓ At the border of each plot respective mungbean genotype was grown to avoid border effect.

**Results**:

**Table 1: List of mungbean genotypes and percentage of plant survived at 25, 35 and 45 days after emergence of seedlings**

| **Genotypes** | % 25DAE | %35DAE | %45DAE |
|---|---|---|---|
| **Samrat** | 56.45 | 40.12 | 20.75 |
| **Sonali** | 52.78 | 39.48 | 15.68 |
| **Sukumar** | 52.18 | 38.46 | 16.45 |
| **Panna** | 60.12 | 40.78 | 21.36 |
| **Birerswar** | 61.78 | 38.45 | 20.13 |
| **Selection -1** | 98.78 | 95.46 | 84.53 |

| | | | |
|---|---|---|---|
| **Selection-2** | 97.89 | 96.78 | 83.12 |
| **TC-39487** | 70.12 | 42.12 | 12.45 |
| **TC-39499** | 68.12 | 40.75 | 12.46 |
| **TC-39544** | 67.23 | 41.45 | 15.45 |

**Table 2: Rescaling value of survival % with grain yield of mungbean genotypes**

| Genotypes | 25DAE | 35DAE | 45DAE | Tatal Score |
|---|---|---|---|---|
| **Samrat** | 0.09 | 0.03 | 0.12 | 0.24 |
| **Sonali** | 0.01 | 0.02 | 0.04 | 0.08 |
| **Sukumar** | 0.00 | 0.00 | 0.06 | 0.06 |
| **Panna** | 0.17 | 0.04 | 0.12 | 0.33 |
| **Birerswar** | 0.21 | 0.00 | 0.11 | 0.31 |
| **Selection -1** | 1.00 | 0.98 | 1.00 | 2.98 |
| **Selection-2** | 0.98 | 1.00 | 0.98 | 2.96 |
| **TC-39487** | 0.38 | 0.06 | 0.00 | 0.45 |
| **TC-39499** | 0.34 | 0.04 | 0.00 | 0.38 |
| **TC-39544** | 0.32 | 0.05 | 0.04 | 0.42 |

## Major Findings:

- The genotype Selection-1 and Selection -2 were showed the maximum value of survival in flooding situation.

## CROP IMPROVEMENT

***Project Title: Genetic improvement of local germplasm used for puffed rice***

**Project code: RRSTZ/Kharif/17-18/08**

**Associate Scientist/s:** Hossain Ali Mondal

***Objectives***

- ✓ Crossing program of the local germplasm, Mala (popular rice variety in Terai zone for puffing purpose) with high yielding variety for creating variability, increasing the yield of grain, developing early maturity variety, developing disease resistant variety, developing insect and pest resistant variety.

**Materials:**

- ✓ Rectified Spirit, Needle, Scissor, Forceps, James Clips, Tags, Polythene Bags, Bamboo Sticks, Conical Flask, Threads, Tob filled with soil etc.

**Methodology:**

- ✓ Selection of female plants- selected Insect and disease free healthy plant
- ✓ Selection of flowers expected to open by next morning
- ✓ Removal of immature and open flowers
- ✓ EMASCULATION - Purpose of emasculation is to prevent pollination. Selection of panicles based on expectation to open in the morning. Lemma and palea cut at a place 25% bellow from the tip. Stamens need to remove one by one with sterilized needle or forceps done at evening. Bagging of emasculated flowers with polythene.
- ✓ EMASCULATION PROCESS- Manual emasculation.
- ✓ POLLINATION- Collection of yellow and turgid anthers from desired male plant and putting them in bright sunlight for 15 minutes. Temporary removal of bag from female plants and pollination is done by dusting pollens over stigma surface of emasculated buds.
- ✓ BAGGING -Fixation of bamboo stick and keep the pollinated flower inside the bag. Two james clip through holes.
- ✓ TAGGING- After bagging tag bear following information. Cross combination (Mala x Gotra) with date of emasculation and date of pollination.

**Results:**

| Female | Male | No of cross |
|---|---|---|
| Mala | Gotra | 3 |
| Mala | ChakhaoSamparark | 16 |
| Mala | Harpidhan | 6 |
| Mala | PB-1 | 15 |
| Mala | Moudamini | 1 |
| PB-1 | Mala | 10 |
| Gotra | Mala | 4 |

Findings:

## CROP IMPROVEMENT

- ✓ The shape of crossed seeds reflects the crossing successful. It needs to be tested in the coming season (2018).

Future Scope

- ✓ Next season, 2018, the crossed seeds will be germinated for F1 generation plants.


Picture 1-3: Pollination was completed, and bagging is followed for getting crossed seeds. Picture 4: Process for maximizing the probability of pollens keeping in sunlight at morning.

## CROP PRODUCTION

**Project Title**: **Improved package of practices for major Agricultural and Horticultural crops in Terai Zone of West Bengal.**
**Project code:** RRSTZ/Kharif/17-18/02
**Associate Scientist/s**: Dr. Parthendu Poddar, Dr. Suchand Datta, Dr. Partha Sarathi Patra

### Package of practices of Green gram (*Vigna radiata L.*) *R. Wilczek*

Green gram is a short duration pulse crop and its contents high amount of protein nearly about 25 percent. The sprouted seed contain ascorbic acid (vitamin, C), these are easily digestible and suitable for patient. The green gram plants may also be used as a green manures, fodder and control of soil erosion.

**Climate: -** Green gram is best suited to areas having annual rainfall of 60 to 70 cm. The crops need hot climate. Mainly green gram is cultivated in kharif and summer season. Ideal temperature is about 25 to $35^0$ C.

**Soil: -** A well - drained loamy to sandy loam soil is best suited for green gram cultivation. Saline and alkaline soils are not suitable for green gram cultivation.

**Field preparation**: - Field is prepared by tractor and then followed by planking. The field should be well leveled and free from weeds. Pre- sowing irrigation should be provided for better germination of seed if there is deficit of soil moisture.

**Seed treatment: -** Seeds are treated with Thiram 75 % or Carbendazim 50 % (Bavistin) or Captan 50% at the rate of 3 gm/kg seeds and it should be done mainly for controlling of seed born disease. If the crop is being taken in the field for the first time or after a long period, it is desirable to treat the seed with suitable Rhizobium culture as well. The use of CRM-6 at the rate of 200 gm per Bigha results more yield.

**Time of sowing: -** Crop is grown during kharif season where sowing is done in last fortnight of June to first week of July. Optimum time of sowing for summer season is last week of February to first week of April.

**Seed rate: -** 4 kg/Bigha

**Method of seed sowing**: - The crop should be sown in line to get higher yield. Line to line distance about 30 cm and plant to plant 10 to 15 cm should be maintained.

**Fertilizer application: -** Various type of organic manures like Vermicompost, FYM and seed cake etc, are applied at the rate of 200 to 500 kg per bigha during land preparation. Soils

of North Bengal are mostly acidic in nature, so application of 100 kg lime or 150 – 200 kg Dolomite per bigha is recommended, one month before land preparation when soil contains sufficient moisture. Application of 5kg urea, 30 kg SSP and 9 kg potash at the time of land preparation is recommended for achieving higher yield. Foliar spray of urea at the rate of 20 gm mixed with one liter water, 30 to 40 days after sowing (DAS), gives higher yield. Spraying of Zink 12% (Chelamin/Chelazink/Trasko) at the rate of 0.5 gm/ L of water 21 days after sowing (DAS) and 20% Borax (Albore/Agribore/Total B-20) at the rate of 1gm/ L of water 28 days after sowing (DAS) helps in improving yield.

**Irrigation: -** Generally green gram does not require irrigation however; under deficit soil moisture condition one pre-sowing irrigation should be given. The first irrigation should be given before flowering stage and second irrigation should be given at the time of pod formation stage.

**Weed management: -** Green gram usually suffers from a severe weed competition up to 35 days after sowing (DAS). Weed do not pose a serious problem during summer, however one weeding should be done at the time of 25 days after sowing (DAS)

**Varity:-** Sonali, Panna, Samrat and Bireswar

**Yield**: - 100-120 kg /Bigha

## Package of practices of Wheat (*Triticum aestivum L*)

Wheat is the second most important cereals crop after rice in west Bengal. Presently wheat area and production is in decreasing trend in our state probably due to dependency of long duration wheat variety and non availability of high quality seed, balance fertilization and irrigation facility

**Climate: -** Wheat prefers cool and moist climate during vegetative growth followed by dry, warm weather to enable the grain to ripen properly. The optimum temperature for wheat growth is between 20-24$^0$C, temperature 16$^0$C to 18$^0$C produced more number of tiller. Excessively high and low temperature and drought are harmful to wheat, cloudy weather with high relative humidity, rainfall and low temperature is conductive for disease attacked like, rust disease.

**Soil:** Wheat is grown in a variety of soil in west Bengal. Loam, sandy loam and silty loam with good drainage facility is ideal for wheat cultivation.

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**Land preparation:** Depending on the nature of the soil land should be ploughed 3 to 4 times with tractors followed leveling of land level with the help of ladder or rotovator. Land must be leveled and subdivided in to different plots to facilitate irrigation. One Pre sowing irrigation should be given 6 to 7 days before the final land preparation in area where soil moisture is lacking. Field should be fee from weeds.

**Time of sowing:** Optimum sowing time is 15$^{th}$ of October to last fort night of November; though sowing time can be extended upto first week of December under late sown condition.

**Suitable variety for Terai Zone:** PPW-343, Deva (K-9107), NW-1012, Rajlaxmi(H.P.-1713), P.P.W-443, H.U.W-468, Satabdi (K-0307)and Purba (H.D-2824)

**Seed treatment:-** Seeds should be treated with carbendazim 2gm or thiram 3gm/kg of seed to control of seed borne disease.

**Seed rate:-**Seed rate are mainly depends on time of sowing and grain weight. Seed rate for timely sown irrigated condition is 13 kg per Bigha. For irrigated late sown condition seed rate is16 kg/Bigha. About 17 kg seed/Bigha is sufficient for surface seeding or broadcasting.

**Manures and fertilizer**: - Application of 700 kg well decomposed FYM or compost, 2 kg Azotobactor and PSB/bigha at the time land preparation. As soil of terai region is acidic, so 150 to 200 kg dolomite/bigha should be applied 3 weeks before land preparation. Under irrigated condition 8 kg nitrogen (17.50 kg urea), 8 kg phosphorus (50 kg single super phosphate) and 8 kg potassium (13.28 kg muriate of potash) per bigha should be applied as basal and 4 kg nitrogen (8.8 kg urea) at 21 DAS and 4 kg nitrogen (8.8 kg urea) 45 DAS respectively should be applied as top dressing.

Fertilizer for late sown condition is 6 kg nitrogen (13.2 kg urea), 7 kg phosphorus (43.75 kg single super phosphate) and 7 kg potassium (11.62 kg muriate of potash). Potassium should be applied in split doses in light texture soil.

In deficient soil application of 2.5 kg sulfur 3.3 kg zinc and 1.3 kg borax/ bigha along with 7 kg organic manure (cowdung or vermicompost) is recommended. In terai region foliar application of 0.5 g ammonium molybdate/L of water is found effective.

**Weed management:-S**everal types of grasses, sedges and broad leaf weeds are found in the wheat field. If weeds are not controlled timely almost 40 % of yield is reduced. Critical stage of crop weed competition is upto 40 to 45 days after sowing (DAS). Therefore 1$^{st}$ weeding

should be done 21 DAS at the time of first irrigation and second weeding should be done at before second irrigation *ie* 42 DAS.

Application of 4 gm Sulfosulfuron 75 WG (Leader)/bigha in 30 litre of water 30 days after sowing, Pendimethalin 30 EC (stomp) @ 3ml/ litre of water 2 days after sowing is beneficial for controlling P*halaris minor*. Care should be taken so that field should have sufficient moisture at the time of herbicide application. For controlling *Chenopodium album* 2, 4-D sodium salt 80% WP (Cut off 80/weedclean) @1.5ml/L of water 35-40 days after sowing is found effective. Application of Isoproturon 75 WP (Arelon, Delron or tritilon) 3 ml/L of water 30 to 35 days sowing is found beneficial for controlling grasses.

**Water management:-** Irrigation is plays an important role for wheat production, though plant cannot with stand water logged condition. Under water logged condition plants become yellow and finally die. Depending on the availability of water, irrigation should be given in the following critical stages.

1. Crown root initiation (CRI) stage (21 DAS)
2. Tillaring stage (45 DAS)
3. Booting stage (50-55 DAS)
4. Heading stage (65-70)
5. Flowering stage (90-95)
6. Milking stage (110-115)

Four irrigations at CRI, tillering, flowering and milking stage is found sufficient for getting profitable yield. CRI is very important stage so if one irrigation is available, that should be given at this stage.

**Harvesting:** Harvesting time of wheat depends upon the variety and type of cultivation i.e. whether rainfed or irrigated. Rainfed crop reaches the harvest stage much earlier than the irrigated crop. It is harvested when the grains harden and the straw becomes dry. Harvesting is done by cutting crop close to ground level with sickle. The plants are tied in small bundles and kept to dry under sun for few days. Threshing is done by trampling under bullocks feeds or by a stone-roller or by thresher. In recent year harvesting id done by reapers in bigger wheat plots in which operations like harvesting threshing, cleaning and bagging are done at same time.

**Yield:** 450 to 600kg/Bigha

## CROP PRODUCTION

### Jute (*Corchorus* sp.)

***Introduction*:** Jute being the second most important commercial fibre yielding cash crop next to Cotton is termed as 'Golden Fibre'. In the present era of hue and cry about the environmental hazards created by the use of synthetics and also to provide employment to the burgeoning population in country like India due patronage should be given to the natural fibers like jute and allied ones which play a very significant role in Indian economy. Area under cultivation of jute is 8.35 lakh ha in the country, which is spread over seven states like West Bengal, Bihar, Assam, Orissa, Meghalaya, Tripura and parts of Uttar Pradesh. About 04 million of farm families are involved in jute farming and an employment to the tune of 10 million paid man-days is generated in this sector.

***Ecological requirement***:

**Soil**: Deep alluvial soil with occasional deposition of silt is ideal for quality fibres of jute. River basin of Jamuna (Brahamaputra at lower stage) and Meghna produces the best quality jute fibre in the world. Gangetic soils in Nadia and adjoining stretches in the Burdwan districts produce better quality jute fibre, In North Bengal, alluvial soils of Teesta, Torsa, Jaldhaka river are suitable for production of fairly good quality fibre.

**Climate:** Well distributed annual precipitation of 1500-2000 mm during the growth stages is ideal / warm humid climate favours high quality of jute fibre. Rains during night and bright sunny weather with mild wind at day time are congenial for jute production. Alternate rain and sun is ideal temperature range for jute cultivation is $24\text{-}37^0$

***Package of practices***:

**Land Preparation**: Land preparation should have the following objectives-

1. Jute seed is very fine. Hence fine tilth is necessary.
2. Jute seed is highly sensitive regarding soil moisture ------ so correct soil moisture regime should be maintained.

   Land preparation is initiated with first north-western shower. After $1^{st}$ ploughing and laddering land is left for 1 week. Weeds come and with $2^{nd}$ ploughing these weeds are removed. The land is ploughed and cross ploughed 4-5 times with necessary leveling. If irrigation is available, one pre-sowing irrigation at final stage of

land preparation is given. Otherwise sowing is done with the receipt of the pre-monsoon showers.

**Varieties:**

**Olitorius**:: JRO-632, JRO-878, JRO-7835, JRO -524, JRO-3690, JRO-66, JRO-8432, JRO-128

**Capsularis**: JRC -321, JRC-212, JRC-7447, Padma, JRC-698

**Sowing parameters:**

Seed treatment: Seed must be treated with or immersed in the solution of fungicides like Captan, Dithane M-45@ 5 gm/ kg of seed / lit. of water for 10 minutes. Then the seeds are shade dried.

- **Seed Rate :**

| **Species** | Line sowing (kg/ ha) | Broadcasting (Kg/ ha) |
|---|---|---|
| **Capsularis** | 6-8 | 10 |
| **Olitorius** | 4-6 | 7 |

- **Methods of sowing**:
  1. Broadcasting
  2. Line sowing
  3. Drill sowing

  Line sowing is advocated for higher yield and economic benefit.
- **Time of sowing**:
  1. Early sowing: In low lying areas where there is a chance of flood sowing may be done on 1$^{st}$ week of March with residual soil moisture.
  2. Normal sowing: Capsularis: 15$^{th}$ March to 15$^{th}$ April

     Olitorius**:** 15$^{th}$ April to 15$^{th}$ May

     Normal sowing with Olitorius Jute starts from middle of April. In case of Chaitali Tossa, it is claimed that sowing is possible from the middle of March, but in areas where there is a possibility of drop in minimum temperature below 20$^0$C there may be pre-maturing flowering. The problem is more common in North

**CROP PRODUCTION**

Bengal areas. Hence for this region sowing of Olitorius Jute should be delayed up to first week of April.

- **Depth of sowing**: 2 cm
- **Spacing**: Capsularis-: 30 X 10 cm
  Olitorius -: 20 X 10 cm

**Weeding**:

It is the most important inter- culture operation of jute because -

1. Weed control consumes a lot of Mondays
2. Weed musty be controlled d at early stages of the plant.

Some points in favour of high rate of weed growth of jute:

i) Jute is grown in warm humid season.

ii) Jute is grown in medium high to high land situation.

iii) The soil is light in texture in many areas.

- **Name of the weeds associated with jute**:

| | |
|---|---|
| *Cyprus rotundus* | *Phyllanthus niruri* |
| *Eleusine indica* | *Cynodon dactylon* |
| *Euphorbia hirta* | *Scoparia dulcis* |

**Methods of weed control**

i) Cultural method: Before final land preparation, land is left for one week to control weeds.

ii) Mechanical method:

   a. Sowing the crop in the row.
   b. Operating wheel-hoe in the rows during early growth stages 3 times at 4-5 days Interval during bright weather condition.
   c. Two hand weeding first at 15-20 DAS, second at 30-40 DAS.

iii) Chemical method: Application of fluochloralin (Basaline) @ 1.5 kg *a.i.*/ha in 500 to 600 liter of water as pre – plant incorporation. After spraying soil should be raked lightly to prevent volatilization.

**Thinning**:

**CROP PRODUCTION**

Thinning of Jute is also very important inter- culture operation. First thinning with 1st weeding and 2nd thinning with 2nd weeding is to be done.

At 50-60 days of crop age, some plants may be found lacking in growth. These plants are thinned, retted and fibre is extracted for family use or sale.

An optimum plant population of five lakh plants/ ha is considered ideal for better yield and quality.

**Irrigation**: Usually jute is grown `as rain-fed crop, sometimes one pre-sowing irrigation is given. If dry spell continues for long time, irrigation may be given during early stages of growth.

**Manuring**: Before fixing the manuring schedule for jute, the following points should be taken into consideration.

Initial soil fertility status

Cropping intensity- in case more than 200 cropping intensity every crop should be manured moderately

Nature of preceding crops:- when jute is grown after potato, very little amount of fertilizer is to be applied for jute. Only moderate quantity of N may be enough for a good crop as potato is manured heavily and residual fertilizer may be enough for jute crop. But when jute is grown after wheat, high amount of fertilizer is to be given as wheat is fairly exhaustive crop.

Physiological growth stages of the crop

| Dose | N | P | K |
|---|---|---|---|
| Capsularis | 60 kg/ha | 30 kg/ha | 30 kg/ha |
| Olitorius | 50 kg/ha | 30 kg/ha | 30 kg/ha |

Sometimes 5-10 tons of FYM / green manuring with Dhaincha or Sunhemp @ 5- 10 t/ha is applied/ ha. For better fibre quality, potash may be given in slightly higher doses.

**Time and method of application**:

1/3 N + full P and K is to be applied as basal. For areas with high rainfall, the 1 st application of nitrogen should be skipped over in order to avoid the encouraging growth of weeds. In

such cases, the 1st application of N is done after 1st weeding. The remaining 2/3 of N fertilizer is applied in two splits at 30 and 45 DAS.

**Foliar application of N:** Foliar feeding of N in case of jute is advised instead of applying 2/3 rd N fertilizer as top- dressing. The following schedule of foliar feeding may be undertaken to save 1/5 of total N fertilizer.

| Age of the Crop | Concentration | Requirement of water/ha | Requirement urea/ha |
|---|---|---|---|
| 3 weeks | 1% | 300 litre | 3 kg |
| 4 weeks | 2% | 500 litre | 10 kg |
| 6 weeks | 3% | 500 litre | 15 kg |
| 7-8 weeks | 3% | 500 litre | 15 kg |

**Liming**: In acid soils of Tripura, Assam and N. Bengal, dolomite containing both Ca and Mg being available in plenty in N. Bengal and Bhutan border area is being considered as superior amendment to neutralize soil acidity. Liming @ 2.5 t/ha (once in a 3 years) or dolomite @ 10-15 q/ ha is recommended when pH is below 5.5. Liming also reduces the root rot and stem rot.

**Micronutrient**: Light soil in N. Bengal deficient in micronutrient particularly Boron needs application of Borax 2 10 kg/ ha. However, its application depends on the cropping pattern also. For example, if mustard or wheat is grown before jute, B application may not be required because B is normally used in mustard or wheat. Olitorius jute has been found to be more sensitive to Boron deficiency than Capsularis, Soil application of Mo @ 400 g/ha or seed soaking with ammonium molybdate @ 90- 180 g/ amount seed required for one hectare or foliar application of sodium molybdate @ 0.5-1.0 g/lit water is advocated. In case of zinc deficiency, $ZnSo_4$ @ 5-10 kg/ha is applied.

**Jute based crop rotations:** Growing of different crops on the same piece of land in a pre-planned succession within a year is crop rotation.

Low land situation:- Jute (capsularis)—rice—wheat

Medium land situation:- Jute (olitorius) – rice--- oilseed / pulses/ potato/ wheat

## CROP PRODUCTION

Under West Bengal condition jute is always followed by transplanted rice in *kharif* and if irrigation is available, a third *rabi* crop such as wheat, potato, mustard and other oilseeds or any *rabi* vegetables is grown.

Solanaceous crops should not be taken after jute because main disease of jute is stem rot of jute caused by *Macrophomina phaseolina*. The sclerotia of the fungus can survive free in soil or dead tissues. If we grow Solanaceous crop after jute, the sclerotia of the fungus may infect the Solanaceous crops.

**Harvesting**:

Depending on the requirement and situation, jute crop may be harvested any time between 100-150 days of crop age. When harvested early, the quality of the fibre is good but yield suffers. If harvested at flowering and early pod formation stage, both quality and yield are optimum. If harvesting is over delayed up to the fruit maturity stage, both quality and yield are drastically reduced.

Capsularis jute is harvested at 120-130 DAS and Olitorius jute at 130-140 DAS.

In low lying areas, Capsularis jute often gets partially submerged after heavy rains in catchment areas. Pre- mature harvesting has to be done in such cases.

High yielding *kharif* transplanted rice is often taken after jute and any one of many *rabi* crops is taken after rice. Hence, a tight schedule is to be followed in such cases. Even Olitorius jute is harvested at 120 days of crop age under such situations.

## Seed production of jute

Jute being a bast fibre crop, both fibre and seed of the good quality can't be obtained from the same crop (plant) and the quality of the fibre deteriorates if the crop is left standing till the seed maturity. Some farmers keep a small portion of the crop at the corner of the field to produce seed and the rest is harvested for fibre. It has been estimated that the average area retained for jute seed production is about 9.1 % the total area under jute cultivation. The seed produced in West Bengal isn't sufficient to meet the demands of jute growers of the state. As a result the major part of the jute seed is supplied from Maharashtra, Gujrat and as joining

areas of Bihar and Orissa. If effort is made, good quality seeds can also be produce in West Bengal in the drier districts of Purulia, Bankura and Midnapur.

**Package of practice**:

- **Seed**: Seed must be procured from National Seed Corporation, WB State Seed Corporation, CRIZAF, Universities or State Seed Multiplication Farms etc. Standard varieties suitable for different agro- climatic regions should be used to raise a seed crop. A good seed sample should have 98% germination at $33^0$ C temperatures.
- **Selection of land**: Same as fibre crop
- **Isolation distance**: Though jute is a self pollinated crop, cross pollination does occur to some extent. It has been estimated that natural cross pollination in the Capsular range from 2-5 % and in case of Olitorius it may as high as 12%. For foundation seed production the seed field should be isolated by 50m whereas in case of certified seed production it is 30m. Isolation distance of only 3 m should be provided between two species of jute.
- **Land preparation**: Same as other fibre crops. The beds should be raised 4-5 cm high with shallow drainage at all the sides to prevent water stagnation. Soil moisture ranging from 21-45% is considered ideal for jute seed germination.
- **Seed treatment**: Same as fibre crop
- **Seed rate**: Same as fibre crop
- **Time of sowing**: July- August
- **Method of sowing**: Line sowing
- **Spacing and plant population**: For a seed crop, profuse branching is encouraged as the no. of flowers, fruits and quantity of seeds would be much more. This is quite in contrast with the fire crop where branching is considered to be a bad trait.
- **Manuring**: The recommended dose for N, P, & K is 15:15:15 (kg/ha) ½ + total P & K is applied as basal. The rest ½ N to be top dressed 1 month after sowing under adequate soil moisture condition.
- **Irrigation**: 1 pre- sowing irrigation + 2-3 subsequent irrigation.
- **Inter – culture operation**: Same as fibre crops
- **Roughing:** Roughing of off-type, diseased and infected plant should be carried out at 30-50 days age of the crop, flowering and capsule forming stage.
- **Pruning**: Pruning apical bud 6 week after sowing induces growth of lateral axillary buds leading to profuse branching. It should be done at a place of the stem 5-7 cm from the top.

## CROP PRODUCTION

- **Cutting**: Stem cutting of the jute easily strike rots when planted in well prepared nurseries. Sometimes farmers harvests a part of jute crop well ahead of the flowering at 90-100 days when the crop has attained 75-80 % of the growth. After harvest of Jute, the apical portion is cut – off and they are planted in well prepared nurseries first and replanted in the main field to get good quality seed and the remaining portion of the stem will portion of the stem will produce good quality fibre.
- **Harvesting**: In case of Capsularis harvesting is to be done when stems and pod are not dead ripe but in case of Olitorius, harvesting should be done when the pods are fully ripe. The procedure is same as in case of fibre crops.
- **Storage**: Seeds should be properly dried till the moisture content of seed reduces to 9 % and the seeds are to be stored in optimum storage condition.
- **Yield** : Capsularis-----3-4 q/ha

  Olitorius----- 1.5 q/ha.

## Turmeric (*Curcuma longa* L.)

**INTRODUCTION :**

Turmeric (*Curcuma longa* L.)is an important rhizomatous spice in India and World too belongs to the family zingiberaceae. Dried rhizome is used as spice. It is basically herbaceous perennial tropical plant however for commercial cultivation itis grown as annual crop. It is used as a condiment, dye, drug and cosmetic in addition to its use in religious ceremonies. India is the largest producer (more than 75% world production), consumer and exporter of turmeric across the world. India has an jealous monopoly over world turmeric trade. Apart from India, it is also cultivated in China, Myanmar, Nigeria and Bangladesh, Pakisthan, Sri Lanka, Indonesia, Mozambique, Jamaica, Haiti, costarica, peru, Brazil, Malaysia, Vietnam, Thailand, etc. During the year 2016-17, India exported about 116500 MT of turmeric and earned a tune of 1241.89 cores of foreign money. The curcuminoids, which include curcumin (diferuloylmethane), demethoxycurcumin, and bis-demethoxy curcumin, are most important chemical components of turmeric. However, the major compound is curcumin, which generally varies from 3-9%, For export purpose, turmeric more than 5% curcumin content is desirable for foreign trade.

**SOIL AND CLIMATIC REQUIREMENTS:**

## CROP PRODUCTION

Turmeric can be grown in diverse tropical conditions from sea level to 1500 m above MSL. It requires temperature ranging from 20 - $30^0$C with annual rainfall of 1500 mm or more. In the Sothern parts of the country it is grown as irrigated crop. However, in the Northern Eastern parts and Northern parts of the country it is grown as rainfed crop. It can be grown on various types of soils from light black, ashy loam, clayey loam and red soils. However, it grows well in a well-drained sandy or clay loam soils. Sandy clay loam soil of terai zone is highly suitable for growing turmeric.

### IMPROVED VARIETIES

A good number of varieties (CO.1, BSR.1, BSR.2, Krishna, Sugandham, Roma, Suroma, Ranga, Rasmi, Rajendra Sonia, Megha turmeric 1, Suranjana, Suvarna, Suguna, IISR Prabha, IISR Prathibha, IISR Alleppey Supreme). have developed from the different research institutes and Agricultural Universities. In Northern parts of West Bengal including terai zone turmeric variety Suranajana is most popular ones.

### LAND PREPARATION AND PLANTING

The land is prepared with the onset of pre - monsoon in the month of April and its onward upto end of May. The soil is brought to fine tilth by giving about four deep ploughings and weeds, stubbles, roots etc. are removed. Beds of size 1-1.5 m width, 15 cm height and of convenient length are prepared with spacing of 50 cm between beds. Small pits are made with hand hoe in the beds in rows with spacing of15- 25 x 30 cm and covered with soil or dry powdered cattle manure. Generally ridges and furrows method is used for planting by keeping optimum spacing of 45-60 cm between rows and 25cm between plants. Whole or split mother rhizomes are used for planting. A seed rate of 2000 kg of rhizomes is required for planting in one hectare. Datta *et al.* (2016) reported that fresh yield of seed turmeric rhizome increased with increasing seed rhizome weight under terai zone of West Bengal. However, the fresh yield of turmeric seed rhizome of 32.00 t/ha was produced with the 50 g ($W_3$) seed rhizome that was statistically *at par* with 35 g ($W_2$) seed rhizome. Significantly the highest fresh rhizome yield was recorded in 20 cm X 15 cm spacing. Considering the interaction effect, the highest quantative and qualitative fresh turmeric seed rhizome yield of 35.43 t/ha was recorded in treatment combination of 35 g seed rhizome planted at a spacing of 20 cm X 15 cm ($W_2S_2$) and that may be recommended for both seed and crop production of turmeric.

## CROP PRODUCTION

Before planting of turmeric rhizome in the main field, it should be treated with suitable fungicides (copper oxy chloride fungicides @ 4g/litre of water, mancozeb @ 3g/litre of water or carbendazim @ 1g/litre of water or bio control agent (*Trichoderma viride*) for a period 30 minutes and thereafter treated rhizome should be dried in shade.

### NUTRIENT MANAGEMENT

Being an exhaustive crop, turmeric requires heavy manuring for higher yield. Cattle manure or compost at the rate of 40 tonnes per hectare is applied by broadcasting and ploughing at the time of preparation of land or as basal dressing by spreading over the beds to cover the seed pits after planting. Recommended fertilizers dose for irrigated crop is 125 kg N, 80 kg P2O5 and 120 kg K2O per hectare. The beds are earthed up after each top dressing with fertilizers.

Jana *et al.* (2017) conducted an experiment to study the efficacy of *Azospirillum* in organic and ntegrated nutrient management with farmyard manure (FYM) and graded levels of nitrogenous fertilizer on turmeric, at Uttar Banga Krishi Viswavidyalaya. The results revealed that application of 75% recommended inorganic nitrogen with *Azospirillum* at 5kg/ha and FYM at 15 t/ha gave the highest yield of 26.29 t/ha as against 22.96 t/ha in the control of recommended dose of fertilizers at the rate of 80:80:120 kg N, P2O5 and K2O per hectare. It was followed by the combined application of 50% recommended inorganic nitrogen with *Azospirillum* at 5 kg/ha and FYM at 15 t/ha with a yield of 25.8 t/ha and then 100% recommended in organic nitrogen with *Azospirillum* at 5kg/ha and FYM at 15 t/ha with a yield of 25.81 t/ha. Highest curcumin content of 5.11% was recorded in organic nutrient management with *Azospirillum* at 5 kg/ha and FYM at 30 t/ha.

Datta *et al.* (2017) studied the effect of different micronutrients on turmeric variety Suranjana in terai region of West Bengal. The results revealed that soil application of boron (as borax) @ 25Kg ha-1) gave the highest yield (11.13 kg/3 m2 and 22.45 t/ha) which was also statistically *at par* with foliar spray of boron as borax @ 0.5% at 60 and 90 days after planting (10.59 kg/3 m2 and 21.36 t/ha). The lowest yield (7.17 kg/3$m^2$ and 14.45 t/ha).was recorded in the control treatment (i.e. without micronutrient application). The highest cost benefit ratio (1: 2.04) was recorded with soil application of boron (as borax) @ 25Kg $ha^{-1}$ followed by foliar spray of boron (1: 1.95).s

Application of all the organic inputs (viz., FYM - 10 kg, Pongamia cake 250 gm, Sterameal 250 gm, Rock phosphate 500 gm, Wood ash 250 gm per 3$m^2$) except neem cake

resulted maximum fresh rhizome yield, although statistically lower from the treatment with recommend dose of fertilizer (AICRP Report).

Datta et al. (2017) conducted an experiment to study the effect of organic source of nutrients and biofertilizers on growth, yield and quality of Turmeric (*Curcuma longa* L.). The results revealed that application of green leaf manure (from *Glyricidia maculata*) @ 12tonnes/ha along with rock phosphate @ 0.2 tonnes/ha, wood ash @ 1 tonnes/ha, *Azospirillum* @ 5kg/ha + PSB @ 5kg/ha ($T_5$) gave the significantly highest fresh (29.27 tonnes/ha) and dry yield (7.81 tonnes/ha) followed by vermicompost 5 tonnes/ha along with *Azospirillum* @ 5kg/ha + PSB @ 5kg/ha ($T_4$) (26.30 tonnes/ha and 6.99 tonnes/ha, respectively) which was statistically *at par* with sole application of 30 tonnes/ha farm yard manure ($T_2$) ( 26.00 tonnes/ha and 6.77 tonnes/ha, respectively). Maximum dry recovery (27.22%) and curcumin content (5.24%) was recorded in the treatment of sole application of FYM @ 15 tonnes/ha ($T_1$).

**INTERCULTURAL OPERATIONS**

The crop is to be mulched with green leaves at the rate of 12-15 tonnes per hectare immediately after planting. It may be repeated again after 50 days with the same quantity of green leaves after weeding and application of fertilizers. Weeding may be done thrice at 60, 120 and 150 days after planting depending upon weed intensity. It could be grown as mixed crop with chillies, colocasia, onion, brinjal and cereals like maize, ragi etc. Irrigation should be depends on the weather and the soil conditions. Under terai zone of west Bengal application surface irrigation, 5cm, and 0.90 IW/CPE ratios gave the highest yield of 20.91 t/ha followed by drip once in 2 days at 40% PE (18.59 t/ha) which was also statistically *at par* with drip once in a day at 40% PE (17.36 t/ha), drip once in 2 days at 60% PE (17.26 t/ha) and drip once in a day at 60% (17.24 t/ha). The highest benefit: cost ratio (2.58) was recorded in application surface irrigation, 5cm, and 0.90 IW/CPE ratios (Report of AICRP on Spices).

**HARVEST AND YIELD:**

The crops become ready for harvest in seven to nine months depending upon the variety. It may extend from January – March. The land is ploughed and the rhizomes are judiciously picked up with a spade. Harvested rhizomes are cleaned of mud and other extraneous matter adhering to them. The average yield comes to 25-30 tonnes of green turmeric per hectare.

## CROP PRODUCTION

After harvesting, turmeric should be processed to improve the quality and storage life of rhizomes.

**Plant Protection**

Yield losses of turmeric mainly affected due to pests like shoot borer, rhizome scales and diseases like leaf blotch, leaf spot and rhizome rot etc.

Rhizone rot :

Seed treatment as well as soil application of *Trichoderma viride* and *Pseudomonas fluorescens* @ 12.5 kg /ha and 25.0 kg /ha as basal and top dressing respectively with application of recommended NPK and FYM was proved to be the best treatment for management of rhizome rot of turmeric (AICRP on Spices report).

Leaf blotch

In leaf blotch experiment, seed treatment as well as spraying with Mancozeb + Carbendazim (0.2% + 0.2%) showed lowest disease incidence and highest yield too. Seed treatment as well as spraying with Carbendazim (0.2%) showed lowest disease incidence and good yield.

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**CROP PRODUCTION**

# Ginger (*Gingiberofficinale* L.)

## INTRODUCTION

Ginger is a slender herbaceous perennial grown as annual crop belonging to Zingiberaceae family. Ginger of commerce founds the dried rhizome of the plant which is used as a spice. It is used in different forms such as raw ginger, dry ginger, bleached dry ginger, ginger powder, sliced ginger, ginger oil, ginger oleoresin, ginger in brine etc. It has usage in foods, beverages, preservatives, medicines and perfumery industries also.

Ginger contains 4.2 to 10.9% oleoresin, 1.6 to 4.4% crude fibre 1.7 to 6% essential oil. The major functional constituent of ginger is zingibarin which can aid immunity and is associated with anti-inflammatory activity. This is due in part to the fact that ginger acts as an antioxidant with more than twelve constituents superior to vitamin E.

## SOIL AND CLIMATIC REQUIREMENTS:

Ginger requires in warm and humid climate. It is mainly cultivated in the tropics from sea level to an altitude of above 1500 MSL. It thrives best in well drained soils like sandy or clay loam, red loam or lateritic loam. Friable loamy soil rich in humus is ideal for ginger cultivation.

### Improved Varieties of Ginger :

Suprabha, Suruchi, Suravi, Himgiri, IISR Varada, IISR Mahima, IISR Rejatha.In the northern parts of West Bengal, Gorubathan is the dominant cultivar followed by Bhaise. Very recently, variety release committee of the XXVII annual Workshop of AICRP on Spices recommended the Ginger Germplasm GCP-49 for national level release as a variety of ginger in the name of UBKV Aada-1 (with popular Name : Mohini). For National release the proposal has been already send to the Central variety Release Commiitttee, Govt. of India, New Delhi.

### Propagation and planting

The land is ploughed 4-5 times to bring the soil to fine tilth and weeds, stubbles, roots etc. are removed. Beds are prepared with a dimension of about one metre width, 15 cm height and of convenient length and distance between beds should be of 50 cm. In case of irrigated crop, the ridges are formed 40 cm apart. Northern parts of West Bengal , it can be planted well in advance during the middle March and may continuedupto Middle of May.

Ginger is propagated by portions of rhizomes known as seed rhizomes. Seed rhizomes weighing 20-25 gm, length of 2.5-5 cm and each having one or two good buds are used for

planting. For planting one hectare area 1500-1800 kg rhizomes are enough and at high altitudes the seed rate varies from 2000-2500 kg per hectare. The seed rhizome bits are place in shallow planting pits prepared with a hand hoe and covered with well rotten farm yard manure and a thin layer of soil and levelled it.

**NUTRIENT MANAGEMENT:**

At the time of planting, 25-30 tonnes well decomposed and dried cattle manure or compost per hectare is applied. The recommended dosage of fertilizer to ginger is 75 kg N, 50 kg $P_2O5$ and 50 kg $K_2O$. N is applied in two split doses, first dose during 40 days after planting and second dose during 90 days after planting while, whole quantity of $P_2O5$ and $K_2O$ are applied as basal dose. Application of neem cake @ 2 tonnes per hectare at the time of planting helps in reducing the incidence of rhizome rot of ginger and increase the yield.

Application of inorganic N 100% + *Azospirillum* 50g + FYM 5 kg per 3 sq.m. plot produced highest yield compared to controls (recommended dose of fertilizer @ 80:80:120 NPK per hectare) in ginger (Annual report of the AICRP on spices).

To evaluate the effect of organic source of nutrients and biofertilizers on growth, yield and quality of ginger (*Zingiberofficinale*Rosc.) datta et al (2017) conducted an experiment at the terai zone of West Bengal. The results revealed that application of green leaf manure (from *Glyricidiamaculata*) @ 12t/ha along with rock phosphate @ 0.2 t/ha, wood ash @ 1 t/ha, *Azospirillum* @ 5kg/ha + PSB @ 5kg/ha ($T_5$) gave the significantly highest fresh (20.68 t/ha) and dry yield (4.52 t/ha) followed by vermicompost 5 t/ha along with *Azospirillum* @ 5kg/ha + PSB @ 5kg/ha ($T_4$) (18.59 t/ha and 4.06 t/ha, respectively). Somewhat higher dry recovery percentage was recorded in case of all the organic treatments compared to control treatment ($T_6$). Maximum dry recovery (22.43%) and oleoresin content (4.37%) was recorded in the treatment of sole application of FYM @ 15 t/ha ($T_1$).

**INTERCULTURAL OPERATION**

Beds are mulched with green leaves to enhance germination as well as to prevent of washing off soil due to soil conservation. The first mulching is done at the time of planting and repeated at 40th day and 90th day after planting with 10-12 tonnes and 5 tonnes of green leaves per hectare respectively. Weeding is done just before fertilizer application and mulching. Two to three weeding are required depending upon the intensity of weed growth. Proper drainage channels are to be provided to drain off stagnant water. Ginger is grown in rotation with other crops such as tapioca, chillies, paddy, gingelly, ragi, ground nut, maize,

vegetables, red gram, castor, etc. It is also grown as an intercrop with coconut, arecanut, coffee and orange plantations.

**HARVESTING AND YIELD :**

The crop becomes mature harvest within eight months and ready for harvesting when the leaves turn yellow and start drying up gradually. The clumps are picking up carefully with a spade or digging fork and the rhizomes are detached from the dried up leaves, roots and adhering soil. The average yield of fresh ginger varies from 15-25 tonnes per hectare depending upon the varieties.

For vegetable ginger, harvesting is done from 6th month onwards. The rhizomes are thoroughly washed in water twice or thrice and sun dried for a day. For dry ginger, the produce is soaked in water overnight and then rubbed well to clean them

**PLANT PROTECTION:**

Shoot borer, leaf roller and rhizome scale are major pests infesting ginger as well as diseases like soft rot, bacterial wilt and leaf spot infecting ginger in the field which affects the quality and yield of the crop.

Rhizome Rot :

Rhizonme rot is the devastrating disease of the ginger. It is the major hindrance for expansion of the ginger area in the terai zone of the West Bengal. In case of rhizome rot, bio-control agent, *Trichodermaharzianum* proved to be the best treatment when applied in soil with neem cake after hot water treatment at 51°C for 10 minutes. The treatment reduced the disease up to 36% in comparison to control. *Trichodermaharzianum*should be applied @ 20 kg / ha mixed with 1 Kg neem cake per 3 m × 1 m bed (Annual report of the AICRP on Spices).

Leaf spot

Leaf spot of ginger caused by *Phyllostictazingiberi*has become a serious phytopathological constraint now in cultivation in the ginger growing areas of India. Among the different fungicides and fungicides combination tested including control for management of *Phyllosticta*leaf spot disease of ginger, Hexaconazole (0.1%) first at disease appearance and then 2 times at 20 days interval produced the lowest leaf spot disease severity (PDI 12.12) followed by spray with 0.1% Propiconazole (PDI 12.95) and spray with mixture of Carbendazim and Mancozeb@ 0.1% first at disease appearance and then 2 times at 20 days interval (PDI 16.83). The highest yield of 6.42 kg/plot (12.94 t/ha) was obtained by 0.1% Propiconazole spray which was very closely followed by spraying with Hexaconazole @

0.1% with a yield of 6.40 Kg/plot (12.90 t/ha). So, it can be concluded that spraying with Hexaconazole or Propiconzole @ 0.1% for 3 times is highly effective against leaf spot disease of ginger.

**INTEGRATED MANAGEMENT OF *PYTHIUM, FUSARIUM* AND *RALSTONIA* ASSOCIATED DISEASES OF GINGER:**

Against *Pythium*, *Fusarium* and *Ralstonia* of ginger, it was found that seed treatment with *Trichodermaharzianum* was the best treatment in reducing the disease over control . This treatment reduced 68.49 % disease over control. However, seed treatment with RidomilMancozeb [100 ppm Metalaxyl] and seed treatment with hot water at $51^0$C for 30 minutes were also very effective against *Pythium*, *Fusarium* and *Ralstonia* of ginger (Annual report of the AICRP on Spices).

It was observed that Bio-fumigation with cabbage recorded the lowest disease of 7.03% - 9.97% soft rot and 5.92 – 10.4% bacterial wilt incidence. This treatment produced the highest yield of 7.02 – 7.52 kg per plot (14.15-15.16 t/ha). Procedure for Biofumigation with cabbage refuse: Since cabbage is cultivated during winter (October–November) in the place where ginger is proposed to be planted in the next season, cabbage may be cultivated and after harvest the leaves and roots are to be incorporated into soil by ploughing. After this the beds are prepared and solarized by polythene mulching for about 15-30 days. Planting with rhizome has to be done after solarization) (Annual report of the AICRP on Spices).

Similarly, Bio-fumigation with mustard also recorded the lowest soft rot (7.16 – 9.44%) and bacterial wilt (6.74 - 10.45%) disease of ginger. This treatment produced the highest yield of 7.18 – 7.53 kg per plot (14.47 – 15.18 t/ha). Procedure for Bio-fumigation with mustard: Beds are to be sown with mustard (during march-April) cultivated for about 30-45 days and the leaves are to be incorporated into soil by ploughing. After this the beds are to be solarized by polythene mulching for about 15-30 days followed by planting with rhizome. (Annual report of the AICRP on Spices).

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**CROP PRODUCTION**

# Chilli (*Capsicum sp* L.)

Chilli (*Capsicum* spp.) is one of the most important vegetable cum spice crops in India and world too. The *Capsicum* genus represents a diverse group of plants, from the well known sweet bell capsicum to the fiery hot chilli. There is tremendous variation in fruit shape, size, colour and as well as in plant habit among capsicum cultivars and species. The name *Capsicum* derives from the Greek word *Kapto*means 'to bite' referring to the pungency or heat of the fruit. *Capsicum* species are the member of the *Solanaceae* family that includes potato, tomato, tobacco, etc. The genus capsicum contains more than 25 wild species and 5 domesticated species among them *Capsicum annuum* and *Capsicum frutescens* are being most commonly grown as cultivated species.

The chief use of chillies throughout the world is as a vegetable cum spice on account of its pungency, colour, pleasant flavour, oleoresin and vitamin content. The alkaloid compounds called capsaicinoids, produced in the fruit, are the main source of pungency in peppers. Capsaicin ($C_{18}H_{27}NO_3$, trans-8-methyl-N-vanillyl-6-nonenamide) is the most abundant one, followed by dihydrocapsaicin,Chilli is widely used in the preparation of various food items. When chillies are taken with food stimulate our taste buds and thereby increasing the flow of saliva which has a great role in digestion of foods. It is rich in vitamin C and vitamin A. The dry red chilli powder or paste which is mainly used everyday in Indian kitchen for preparation of curries, sambar, dalna and many other fish or meat dishes to impart pungency and colour. It is also an important ingredient of curry powder, curry paste and all kinds of pickles, sauces, soups, salads, sausages etc. In food and beverage industries, chilli is being used in the form of oleoresin which permits better distribution of colour and flavour in foods.

The most important chilli growing countries are India, China, Egypt, Ghana, Nigeria, Tunisia, Itali, Mexico, USA, Argentina, Indonesia, Bangladesh, Pakistan, Sri Lanka, Turkey, Hungary, Romania, Spain and Bulgaria. In India, it is cultivated in an area of about 7.92 lakh hand with a production of 13.75 lakh MT. In West Bengal it is cultivated in 63000 ha and witha production of 1.00 lakh MT (Geetha and Selvarani, 2017). During 2016-17, India earns about a tune of 3997.43 crores by exporting chilli and chilli products (Anonymous, 2017).

**Soil and climatic requirements:**

Chilli can be grown in wide range of soil starting from lateritic loam to black soil. However, it can be grown best in sandy loam soil with moderate pH. Friable and loose soil

with good drainage is ideal as oxygen demand in root is more. Water stagnation for short duration also results in yellowing and shedding of leaves. Blossom end rot is a common phenomenon in heavy soil.

It is basically warm loving plant, although it is grown in wide range of climates.. Warm areas experiencing well distributed 60 to 150 cm rainfall is suitable for chilli cultivation. Erratic and heavy rainfall is very detrimental for its growth and fruiting. Plant can withstand high temperature during growing period but fruit setting is hampered due to high temperature and heat wave. 21$^{o}$C temperature is ideal for vegetative growth of the plant and 26.7$^{o}$C is best for good fruiting. Desication of flower and fruit drop is common during heat wave.The climatic condition of terai zone is sub-tropical humid in nature characterized by high rainfall, high relative humidity, moderate temperature, prolonged winter with high residual soil moisture is highly suitable for growing chilli.

**Nursery operations:**

Fungicide treated (Carbendazim @ 1g per kg of seeds) seed should be sown in the well prepared nursery beds. In case of rabi season crop seed should be sown form last week of September to Middle of October and for Kharif season crop seed should be sown end of February to last week of March. Nursery raising of seedlings is done in raised beds situated in high land with light sandy loam soil. The area is ploughed for 3-4 times to get fine tilth and leveled after removal of weeds and clods. Beds of 1.2 m width and convenient length raised to 15 cm are prepared for sowing seeds. Seeds are generally sown in lines at a distance of 10 cm and at a depth of 1.5-2.0 cm. Seeds are treated with fungicides (Agrason-GN or Copper oxychloride solution) before sowing. Watering is done just after sowing of seeds and seed beds are often covered with rice straw or other mulches for better and quick germination which is also removed just after completion of germination. After sowing, seeds should be covered with fine layer of farm yard manure. Light irrigation can be given, when bed showed insufficient moisture. Timely application of insecticides and fungicides should be arried out depending upon the incidence of pests and diseases. Seed rate is 1.0 to 1.5 kg/ha that should sown in a nursery bed of 200-250 square meter.

Transplanting of seedlings is the better method for chilli production. Seedlings become ready within 30 to 40 days after sowing of seeds to transplant in the main field. Chilli can also be grown by direct seeding method. For better establishment of seedlings in the main field irrigation in nursery bed should be stopped 7-10 days before transplanting and only stought, straight seedlings should be transplanted during the cloudy evening. A light

irrigation is necessary after transplanting. Seedlings are normally planting at a spacing of 45 to 60 cm between lines and 30 to 45 cm within lines depending upon the variety, water and nutrient management practices.

**Variety:**

A large number of variety including F1 hybrids have been developed form the different Research Stations, Agricultural Universities and from Private Sector. PusaJwala, PusaSadabahar, Bhagyalakshmi (G-4), Andhra Jyoti (G-5), Sindhur (CA-960), Pant C-1, Punjab Lal, KashiAnmol, ArkaMeghana (F1 Hybrid), ArkaHarita (F1 hybrid), Pragati, NS 1701, NS 7510, Indam-5, Indam-6, Tejaswan, SARPAN F1. hyb. Chilli SH-26, SARPAN F1.hyb. Chilli SH-48, SARPAN F1.hyb. Chilli SH-60 is some of the important varieties of the chilli. Bowa, Akashi and Suryamukhi are also very popular cultivar in the terai zone of West Bengal. Different research programme was undertaken for selection of suitable varieties of chilli under treai zone of West Bengal.

Datta and Jana (2009) reported that in *rabi*season, the highest number of fruits and fruit yield was observed in 'Ulka686F1 ' (232.24 and 21.00 tonnes/ha, respectively) as compared to 'Jwalan' (206.53 and 16.23 tonnes/ha, respectively) and 'CA 29' (174.63 and 15.50 tonnes/ha, respectively). Similarly, in *kharif*season, the highest fruit yield was recorded in 'Jwalan' (12.08 tonnes/ha) followed by 'Ulka 686 F1 (11.27 tonnes/ha) and 'PusaSadabahar' (9.53 tonnes/ha).

Datta and Jana (2012) reported that during *rabi* season the highest fresh green fruit yield was recorded in Ulka 686 (15.98 t/ha) and was specifically adopted under favourable condition (higher fertility level). Higher yield was also recorded by Jwalan (15.68 t/ha ), CA-29 (14.76 t/ha) and CA-48 (13.92 t/ha) but these genotypes were not stable under changing environment as their s d value was significant. Among the high yielding genotypes CA-47 (14.81 t/ha), NS-1701 (13.06 t/ha) performed better under favourable condition and the genotypes Tejaswini (10.65 t/ha), DKC-8 (10.10 t/ha) and CA-30 (10.01 t/ha) performed better under adverse (lower fertility level) condition.

**Nutrient Management**

Chilli requires a high amount of manures and fertilizers since it is long growing season (more than 6 months) crop. Among the different major nutrient, it responds well to nitrogen and potash rather than phosphorus. But respond depends upon the inherent fertility status of the soil. Apply higher amount of nutrient under irrigated condition than the

rainfedcondition. Response of chilli crop to fertilizers depends upon the variety (local types or named variety or $F_1$ hybrids), type of soil, fertility status of the soil and soil moisture. Normally 15-20 tonnes of well decomposed farm yard manure or compost applied at the time of final land preparation. For .irrigated transplanted crop apply 100 kg N, 50kg P & 50 kg K should be applied per hectare. Half of the nitrogenous fertilizers are applied as basal during land preparation along with full phosphatic and potasic fertilizers. Remaining nitrogenous fertilizers are applied in two equal splits at 45 days and 90 days after transplanting.

Talukder and Jana (2009) reported that the growth, yield and quality characters of green chilli crop increased with the inoculation of biological nitrogen fixers using *Azotobacter* and *Azospirillum*. Performance of *Azospirillum* was better as compared to Azotobacter. Dual inoculation gave a synergistic effect in increasing crop growth and yield. Dual inoculation with the biological nitrogen fixers, 100% recommended dose of N-fertilizer @ 80 kg N/ha and farmyard manure @ 15tonnes/ha recorded maximum growth, yield (7.43tonnes/ ha) and quality parameters, and cost : benefit ratio of 1.55 and no significant difference was observed when N-fertilizer level was reduced to 75%. Thus associative nature of the above biofertilizers helped to save 25% nitrogenous fertilizer in chilli crop. There was increased content of residual available soil nitrogen (202.90 kg/ha), phosphate (67.10 kg/ha) and potash (70.50 kg/ha) with dual inoculation with the biological nitrogen fixers along with full dose of N-fertilizer.

Datta and Jana (2009) conducted an experiment on the effect of seasons and fertility levels on yield and quality of chilli (*Capsicum annuum*L) genotypes in teraiagroclimatic region. According to them performance of genotypes Ulka 686 $F_1$ (24.85 t/ha), Jwalan (19.96 t/ha)and CA-29 (19.28 t/ha)were selected for growing at 150% Recommended Dose of Fertilizer(RDF) (RDF is 100 : 50 : 50 Kg N , $P_2O_5$ and $K_2O$ kg/ha, respectively). Similarly for kharif season genotypes Jwalan (12.20 t/ha), Ulka 686 $F_1$ (11.25 t/ha) at 100% RDF and PusaSadabahar at 150% RDF (10.43 t/ha) were selected.

Datta and jana (2014) found that there was a significant variation in nitrogen (N), phosphorus (P) and potassium (K) content and their uptake by different plant parts with respect to growing seasons, fertility levels and genotypes. Similarly, N, P and K content and uptake (except fruit N and fruit P uptake) increased with increase in the levels of soil fertility from 0 to 200% of recommended dose of fertilizers (RDF). Considering yield performance of different genotypes, 'Ulka 686 F1' (24.9 t/ha), 'Jwalan' (20.0 t/ha) and 'CA-29' (19.3 t/ha),

were selected for growing at 150% RDF in the winter season (low temperature and low rainfall regime). Similarly for rainy season (high temperature and high rainfall regime), 'Jwalan' (12.2 t/ha), 'Ulka 686 F1' (11.3 t/ha) at 100% RDF and 'PusaSadabahar' at 150% RDF (10.4 t/ha) were selected. Highest amount of total N, P and K uptake of 158.55, 68.51 and 195.35 kg/ha, respectively was recorded by Ulka 686 F1 at 200% RDF. Partioning of nutrient revealed that fruit N, P and K content increased with increasing fertility level upto 150% RDF in winter season and 100% RDF in rainy season thereafter decreased subsequently. Stem N, P and K percent increased with increasing fertility level whereas reverse case was noticed in the case of root N, P and K content irrespective of season.

**Intercultural operation**

After transplantingone light irrigation was given for quick establishment of seedlings and there after irrigation was given as and when required. Weeding, hoeing, staking and other intercultural operations were also done as and when required. Chilli can not tolerate moisture stress as well as excess moisture in the soil. Thus judicious irrigation is necessary depending upon the condition of soil. Ten leaf stage, flowering and after each periodical harvest are crici stage of irrigation for chilli crop. Irrigation should be given in these stages if soil moisture is deficit. Generally fortnight irrigation during winter and weekly irrigation during summer is generally recommended. Additionally to keep the crop free from weed, 2 hand weeding and 3 hoeing is necessary for keep the field free from weed and loosening of the soil, respectively.

Sarkar*et al.* (2007) carried out an experiment on pinching on chilli. According to them pinching at 30 days after transplanting increased number of branches led to production of more number of flowers which ultimately produced more number of fruits as a result yield of the pinched treatment increased about 17 per cent fruit yield.

**Harvest ing:**

Harvesting of chilli was done at the mature green stage when a few number of fruits change colour from green to red considering consumer preference. Harvesting of the mature fruit was done at 15 days interval. But in case of dry chilli production, fruits are harvested when they are partially dry on the plant.

**PLANT PROTECTION**

**PEST**

**Whitefly (**Bemisiatabasi Gen) :Both adults and nymphs suck the sap from the lower surface of the leaf. Due to sucking chlorotic spots develops, leaves become brittle and drop prematurely. Honey dew secretion results in sooty mould development in the leaf.

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Using a diluted soap mixture and manually removing infected leaves is the best method, although it can take many weeks to eradicate the infestation. It can be managed by spraying neem oil or by spraying systemic insecticides

**Thrips**(*Scirtothripsdorsalis* Hood) :It is an important pest of chilli. Both adults and nymphs of these insects suck sap from tender leaves growing shoots and young fruits. As a result of thrips infestation, leaves become smaller, thickened, curled upward and brittle.

Avoid chilli and onion mixed cropping. Seed treatment with withimidacloprid 70% WS @ 8 g /kg of seed. Apply carbofuran 3% G @ 33 kg /ha or phorate 10 % G @ 10 kg/ha or spray systematic insecticides like Imidacloprid 17.8 % SL @ 3.0 ml/10 litre of water or Dimethoate 30 % EC @1.0 ml/litre of water.

**Mites** (*Polyphagotarsonemuslatus* Banks) **:**Both nymphs and adults suck the sap from young foliage and growing tips. Due to the sucking downward curling of leaves giving an inverted boat shaped appearance, stunted growth, elongation of Petiole is very common with reduced fruit size.In severe infestation, scarring of the stem and fruit skin is noticed.

The peast can be managed by growing resistant/tolerant varieties S-7, Pant C1 and Pant C2, Dh-7-6-6, Jwala, 21-8, IIHR-243-1-1-5 and Musalwady selection has been found resistant for mites. Frequent overhead watering of plants during the dry weather helps to reduce the pest population. Spraying with miticides such as Dicofol @5 ml per litre or wettable sulphur 3 grams per liter or Pegasis @ 1 gm per liter or Vertemic @ 0.5 ml per litre is very effective for management of the pest. Apart from sulphur containing compounds some other insecticides like monocrotophos and phosalone having the acaricidal properties.

**DISEASES**

**Cercospora leaf spot** (*Cercosporacapsici*): Both in nursery and main field may be affected by this foliar disease. Leaf lesions typically are brown and circular with small to large light grey centres and dark brown margins. The lesions may enlarge up to 1.0 cm or more in diameter and sometimes coalesce to each other. Stem, petiole and pod lesions also have light grey centres with dark borders, but they are typically elliptical. Severely infected leaves drop off prematurely resulting in reduced yield.

Spray twice at 10-15 days interval with 2.5g Mancozeb or 1g Carbendazim/litre of water to effective management of the disease.

**Bacterial Leaf Spot**(*Xanthomonasvesicatoria*) : This disease is mostly prevalent during the post rainy season. Leaves, stems and fruits are affected by this disease. On young leaves the

spots are yellowish green but on older leaves they are dark and water soaked. Narrow, elongated lesions or streaks may sometimes develop on stems Water soaked spots appear on green fruits and sometimes small blister like spots appears on the fruit and ultimately becoming warty in appearance later.

Seed treatment with corrosive sublimate and crop rotation may reduce the incidence of the disease. The nurseries and plants in the mainfield may be sprayed with a copper fungicide such as Bordeaux mixture. Spraying Agrimycin - 100 k at 200 ppm plus Copper Oxychloride 0.3 percent in the main field may manage the disease effectively.

**Damping off (***Pythiumaphanidermatum*) :This is very common and serious disease in chilli seedlings and mostly occurs in nursery bed. This disease is commonly noticed in n moist soils with poor drainage. Due to the incidence of the disease seed may rot or the seedlings may be killed before they emerge from the soil. The seedlings affected with this disease rot at ground level and then the plants fall over ground. In nursery bed the disease may appear in patches in 2-4 days, the entire lot of seedling may be destroyed.

Partial sterilization of soil by burning trash in the surface or by formalin treatment before sowing is effective for management of this disease. Soil drenching with 1% Bordeaux mixture or CopperOxychloride @3 g/litre of water at 12 and 20 days after sowing is also useful. Seed treatment with 3g Captan or Thiram/kg seed or by 4g *Trichodermaviride* formulation combined with 6g Metalaxyl is highly effective.

**Anthracnose / Die back and Fruit rot** (*Colletotrichumcapsici*) :

It is most common fungal disease of chilli. . It is mostly appeared on ripened fruits and hence the disease is also called as ripe fruit rot. The spots are usually circular, water-soaked and sunken with black margins. When these spots occur, the fruits rot and drop off prematurely resulting in heavy loss of yield.Moist weather, shade and heavy dew favours the occurring and spreading of this disease. The fungus may attack on twig portion of the plant and cause “Die back" symptom. Dieback symptom also spread gradually from the top to downward portion of the branches and ultimately branches dry up.

Use disease free seed and seed treatment with 3g captan or mancozeb/kg of seed reduce the incidence of this disease. Removing and burning of attacked plants or branches and spraying the disease affected crops with mancozeb @ 2.5 g or copper oxychloride @ 2.5g and carbendazim at 1 g litre of water are the control measures for this disease

**Leaf Curl :** It is a viral disease and mainly transmitted by chilli thrips and aphids. Affected leaves become small in size and the leaves turn downward and become curly. The leaves may fall off in case of severe attack. The disease usually spreads through insect vectors such as thrips and etc.

The infected plants should be uprooted and burnt or buried into soil to avoid further infection. Avoid monoculture of chilli crop. Nursery beds should be covered with nylon net to protect the seedlings from vector of this disease. Selection of healthy and disease free seed. Suitable insecticidal (Dimethoate or Monocrotophos @ 1 ml/ litre of water or Imidacloprid @ 1ml /3 litre of water) sprays reduce the ncidence of viral diseases, since majority of viral diseases are transmitted by insect vectors.

**Fusarium wilt** (*Fusariumoxysporum*f.sp. *capsici*) : This fungal disease is characterized by wilting of the plant and upward and inward rolling of the leaves. The leaves turn yellow and die. High temperatures and wet soil conditions favour disease development. It is mostly occurred in poorly drained soils.

Water stagnation should be avoided by creation provision of drainage to control this disease to some extent. Drenching with 1% Bordeaux mixture or copper oxychloride may also helpful. To manage this disease seed treatment with *Trichodermaviride* formulation @ 4g/kg of seed or carbendazim @ 2 g /kg seed is effective.

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## CROP PRODUCTION

### BLACK PEPPER

Black pepper (*Piper nigram*L.) is one of the oldest and world most important spices and is called King of spices. The word "Peperi" in Greek, Pepper in English and Greek and Piper in Latin were derived from the Sanskrit word "Pippali" which was the name of Long Pepper. It is indigenous to the tropical forest of the Malabar Coast from where it is spread throughout the tropics. India has the largest area under this crop (2.17 lakh ha) and it is the largest producer (65000 MT). Northern parts of the west Bengal, particularly terai zone is suitable for cultivation of the black pepper.The alkaloid principle piperine is considered to be the major constituents responsible for the pungent and bitter principle of black pepper. It is absent in the leaves and stems of pepper plant. The curse piperne varied from 4-10%. The essential oil content varied from 2.5 to 4.5%. Black pepper constitutes an important component of culinary preparation and seasoning and as an essential ingredient of numerous commercial food stuffs. It acts as an preservative for meat and other perishable food preservation. It is an important constituent of whole, pickling spice, curry powder and spice formulae for seasoning sausages, poultry dressing, hamburger etc. Pepper oil is used as a valuable food adjunct for flavouring agent in different food stuff, beverages, liquors. It is also used in perfumery and medicine industries. Piperine is used to impart pungent test to brandy. Oleoresin also used as flavouring agent.Black pepper and its oil are used to cure dyspepsia, malaria, cold cough etc. it also helps in improving the impotency and muscular pain.

**Soil :**

Crop grows well on soils ranging from heavy clay to light sandy clays rich in humus and friable in nature, well drained but good water holding capacity. Soils with high organic matter and high base saturation with Ca and Mg enhances the productivity. Soil PH should be 4.5 to 6.0 and soils with PH above 7.5 inhibit growth. Loamy humus nourishes the crop well but the best crop could be obtained in virgin forest soil.

**Climate:**

Black is a plant of humid tropics and requires a heavy and well distributed rainfall and high temperature. It grows successfully between $20^0$N and $20^0$S of equator and upto 1500 m MSL, but thrives best at 500 m or below. Being a tropical crop, pepper requires 200-300 cm rainfall and high relative humidity with a little variation in day length throughout the year. A relative humidity of 60-95 % is optimum at various stages of growth. Rainfall of 70 cm

received in 20 days during May – June proves sufficient for triggering off flushing and flowering process in the plant. But once the process is set off, there should be continuous shower until fruit ripening. Any dry spell even 4 days within this critical period of 16 weeks results in low yield. The crop may tolerate temperature between 10-40$^0$C and ideal temperature is 23-32 $^0$C with an average of 28$^0$C. Optimum temperature for root growth is 26-28$^0$C.

**Propagation :**

Black pepper is propagated by cuttings raised mainly from the runner shoots. Recently serpentine layering is practised for getting higher number planting materials from the single plants. Datta*et al.* (2008) conducted an experiment at UBKV, pundibarito find out the best time for propagation of black Pepper through runner vine cutting. This experiment was conducted from 18$^{th}$ February with ten days interval and continued up to 18$^{th}$ of June with cuttings taken from middle portion of the runner vines. Success in rooting of cuttings found to be increased from February onwards and it was maximum (92.67%) during 3$^{rd}$ week of March and decreased thereafter. Low temperature during February hinders the rooting of cutting, whereas moderate temperature thereafter enhances rooting. Maximum number of roots per cutting (9.97) was recorded when cuttings are taken during end of March. The higher length of new shoot and leaf number was recorded during the second fortnight of March and it was lowest in 3$^{rd}$ week of June. Propagation of Black Pepper through cutting may be taken up from mid March to end of April with a success rate of 70% and above.

**Fertilizer requirement :-**

The amounts of macro and micronutrients removed through harvested produce were directly proportional to the yield, indicating the need for yield based fertilizer recommendations in black pepper. The magnitude of nutrient removal by harvested produce followed the decreasing order : N>K>Ca>Mg>P>S>Fe>Mn>Zn. Apply N : $P_2O_5$ : $K_2O$ @ 100:40:140 g/mature vine/year. Apply 1/3$^{rd}$ dose for one year old plant, 2/3$^{rd}$ dose for 2 year old plant. The full dose is given from the 3 years and onwads. The fertilizer may be applied in split doses first in May – June with receipt few soaking rains and second in August – September. Apart from the inorganic fertilizers apply FYM/ compost at the rate of 10 kg per vine. It is desirable to apply lime @ 500g/ vine in April – May in alternate years, fertilizer are to be applied (on northern side) at a distance of 30 – 45 cm away from the vine (in semicircular band) and cover with a thin layer of soil.

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**Irrigation :**

Sufficient soil oisture enhances the entry of water in plant system and better translocation of nutrients for the metabolic activity of the plant. Irrigation should be provided during the rainless period from November to March to getting higher yield and productivity of the crop.

**Cultural Practices:-**

As the cutting grows, the shoots are tied to the standard as often as required. The young vine should be protected from direct hot sun during summer by providing them with artificial shade. Regulation of shade by lopping the branches of standards is necessary not only for providing optimum light to the vines but also for enabling the standards to grow straight. Adequate mulch with green leaf or organic matter should be applied towards the end of north-east monsoon. The base of the vines should not be disturbed as to avoid root damage. In the second year, practically the same cultural practices are repeated. However, lopping of standard should be done carefully from the $4^{th}$ year onward, not only to regulate the standard but also to shade the pepper vines optimally. Excessive shading during flowering and fruiting encourage pest infestation. From the forth years and onwards usually two diggings are given during onset and end of South West monsoon. Growing cover crops like *Calapogoniummucunoides, Mimosa invisia* are also recommended under West Coast conditions to provide an effective cover to prevent soil erosion during rainy season. Further they dry during summer, leaving a thick organic mulch.

**Harvesting and Yield:**

Flowering in pepper starts during May – June. The crop takes about 6-8 months from flowering to harvest. The harvest season extends from November to January in plains and January to March in hills. During harvesting the whole spike is handpicked when one or two berries in the spike turn orange or purple. Harvesting in immature stage reduces bulk density. The berries are separated from spike and dried in sun for 3 to 5 days. The average yield of black pepper (dry) obtained from vines under ideal management conditions is 2 kg/year. However yield varies with age, vigour of vine, cultivars, edaphic condition and management level. The dry recovery of pepper varies from 30-35% depending upon the variety.

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To improve the colour and appearance of dry berries and reduce the drying time, harvested green pepper is to be soaked in hot water and then dried in sun. it also minimizes microbial contamination and gives hygienic product which can be preserved easily.

**Bush Pepper :**

Black pepper can be grown as bush in pots known as bush pepper. In this case fruiting branches are used as planting materials. Bush pepper produces flower and fruit in the same year. The also continue to flower around the year.

One year old healthy fruiting branches are selected with 3-5 nodes and all the leaves are removed. The cuttings are treated with 0.2% copper oxy chloride for 20-30 minutes. The lateral should be given a slanting cut 2 cm below the nodal region and dipped in 1000 ppm IBA for 45 seconds and planted in shaded area in the nursery either in trenches or in poly bags (45X30 cm) containing moist decomposed coir dust. After planting, the trenches are covered with polythene sheets and in case of poly bags, the mouth id tightly tied to avoid moisture loss.

After 30-50 days these rooted cuttings are planted in pot or in field after sufficient hardening treatment. Swaminathan and Pillai (2000) reported that pepper grown in pot has longer spike but where as pepper grown in field condition has more number of spikes per bush and yioeld of green and dry pepper is also higher. This could be grown as an inter crop in the coconut and arecanut gardens and bund crops. A quantity of 2-5 kg FYM along with 10g NPK @ 1: 1: 2 ratio may be given per bush at 3 months interval. Watering and plant protection may be adopted according to necessity.

Variety :Karimunda, Panniyur -1, Subhakara, Sreekara and Kottanadan.

Yield : On an average 500 g to 1 kg of green pepper can be harvested during 2$^{nd}$ year of planting. Yield increase with the advance of age.

**Curing of black pepper :**

After harvesting the spikes are heaped for 1-2 days and the berries are separated from the spikes and dried in the sun for 4-5 days on mats or clean concrete floor, until the outer skin become dark brown to black and shriveled. To improve the colour and appearance of dried berries and to reduce drying time, harvested green pepper is to soaked in boiling water for one minute and then dried in shade. During drying blackening occurs due to enzymatic oxidation of phenols, which present in epicarp and mesocarp.

**Physiological disorder**

**Spike shedding**

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Spike shedding in pepper, has so far, been considered as a natural phenomenon. Sometimes spike shedding occurs to the extent of 14 to 65% causing considerable loss. Though it occurs through out the period from emergence of spike to harvesting of berries. But it is high in after fertilization and in advance stage of fruit development.

**Factor affecting Spike shedding :**

i) Genetic character of the plant.

ii) Imbalance of nutrient status

iii) Climatic factors (Prolonged dry spell or heavy rain or sharp alteration of two).

iv) Disease and pest infestation.

**Control :**

i) Selection and multiplication of vine showing least tendency for spike shedding eg. Panniyur-1, Kalluvally, Cheriyakaniakadan.

ii) Adopt suitable management, cultural and plant protection measures.

iii) S[praying IAA 100 ppm or Planofix 50 ppm or Zinc 0.5% at the time of berry setting stage reduces spike shedding.

**Diseases and Pests :**

**Pests**

**Pollu beetle :***Longitarsusnigripensis*

It is the most destructive pest and more serious in black pepper plantations in the plains and lower altitude. The adult and grub feed on the growing points, tender shoots, tender and mature leaves, tender spike and berries. It can be controlled by spraying @ 0.05% quinalphos during June-July and September – October is effective in controlling the pest.

**Top ShhotBorer :***Cydiahemidoxa*

Cater pillar bore into the tender shoot turning them to black and dry.

Spraying 0.05% endosulphon two tomes should be done when new shoots emerge.

**Gall thrips :***Liothripskarnyi*

Affected leaves become thick, malformed and crinckled

**Scale insect :**

Drying the the infested portion of the vine

**Control :** Can be controlled by spraying monocrotophos @ 0.05% or dimethoate @0.05% is effective against gall thrips and scale insect.

**Nematode :**

Root Knot nematode :*Meloidogyne incognita*

Burrowing nematode :*Radopholus similes*

Both species infest black pepper. The aerial symptoms are foliar yellowing, defoliation and dieback. The affected vines exhibit varying degree of root degeneration and folir yellowing from October onwards coincide with depletion of soil moisture. With the onset of S-W monsoon some of the affected vines recover and put forth fresh foliage. However the symptoms reappear in subsequent season after the cessation of the monsoon.

Application of 2 kg neem cake along with Thimate 10G @ 30 g or Carbofuran 3G @ 100g per vine twice in year.ie. One in May –June and other during September - October check the nematode population.

**Diseases :**

**Foot rot or quick wilt :***Phytophthora capsaicin*

Feeder root infestation results in varying degree of root rot symptom and ultimately leading to foliar yellowing. Root rot finally lead to the foot or colar region and ultimately vine dies. Foliar infection results in dark brown leaf spots with fast advancing margin and this appear during June –August. Stalk of the spike and berries also infected resulting in spike shedding. Foliar infection leads to defoliation. High soil and atmospheric humidity during monsoon favours infection and spread.

- Adopt appropriate cultural and phytosanitation measures.
- Pre and post monsoon application of *Trichodermaharzianum* @ 50g/vine and 1 kg neem cake reduce disease incidence
- Pre and post monsoon spraying of Bordeux mixture @ 1% and drenching with Cu Oxy Chloride (0.4%) or Akomin (0.2%) is the prophylactic measure to check the disease spread.

**Pollu disease or anthracnose :***Colletotrichumgloeosporides*

When infection occurs on berries it splits and further growth is restricted. Sometimes brownish circular spot appear. When infection occurs on spikes, spike shedding occurs, resulting in heavy crop loss.

- Pre and post monsoon spray with Bordeaux mixture (0.1%) given against foot rot infection would be enough to control this disease.

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## CROP PROTECTION

**Project Title**: **A Review on the Occurrence of Pests and Diseases of major crops and Their Management in Terai Region of West Bengal**

**Project code:** RRSTZ/Kharif/17-18/01

**Associate Scientist/s**: Dr. Suprakash Pal, Dr. Nilanjana Choudhuri, Dr. Satyajit Hembram

### 1. Introduction

The terai agro-ecological zone which comprises the northern part of WestBengal lies between 25 longitude E′54°E to 58′25°N latitude and 88° N to 27′57°. The terai zone is situated in Sub-Himalayan plains comprising Kurseong, Kalimpong and Bhutan Hills in the North, Bihar border in the West, Assam border in the East and Bangladesh in the South. The zone includes Siliguri and Islampur sub-divisions of Darjeeling and North Dinajpur district respectively and entire Jalpaiguri and Cooch Behar district. Out of 12,025 sq.km geographical area of the zone 8,567 sq.km is brought under cultivation. Total geographical area of terai zone is about 13.5% of the state area which support 9.7% of the state population. Rural population exceeds the average state figure which is more than 90%.

For the overall development of agriculture in the terai region the Executive Council of Bidhan Chandra KrishiViswavidyalaya approved the establishment of North Bengal Campus along with an agricultural research station and KrishiVigyanKendra in 1979. An area of 305.05 acre was acquired by the West Bengal government at Pundibari for that purpose. Along with this the block seed farm of 25 acre also came under the jurisdiction of BCKV. The campus was started at the Gram Sevak Training Centre, Cooch Behar in February, 1979 with Professor T.K. Bose as the Professor-in-charge. The B.Sc.(Ag.) course was started in 01.03.1979. The foundation stone for the construction of North Bengal Campus at Pundibari was also done in 1979. After 10 years the inauguration of North Bengal Campus at Pundibari was done on 27.12.1989. Then full-fledged Uttar BangaKrishiViswavidyalaya was established in February, 2001.

The Regional Research Station for Terai Zone was established by the state Govt. under the North Bengal Campus of BCKV in 1978 with an objective of catering the research need of agriculturally backward northern tract of the state. The RRS set up established by the State Govt. at Pundibari was subsequently strengthened by NARP back up. Adding of a few AICRPs has also become helpful to gain its further strength. Research activities in its true sense of term were started from 1990 with implementation of NARP. A good number of technologies have been generated from the research under NARP, AICRP and Ad-hoc research projects during the period. The RRS from its very beginning has its uniqueness in organizing need-based research by involving all categories of teachers in multidisciplinary

teams and by extending assistance in the field and laboratory in co-ordinated manner. This review discusses the work done on the pest infestation and their management in the major crops grown under the jurisdiction of this zone.

**Present thrust areas of research:**

1. Characterization of plant genetic resources for breeding/selection
2. Strengthening of soil microbial inventory through exploration cum conservation
3. Crop based performance studies on productivity, stress tolerance and seasonal sequencing
4. Strengthening of secondary farm data base for referral use
5. Exploration of production impediments of livestock enterprise
6. Exploration/development/standardization of farm fishery technology

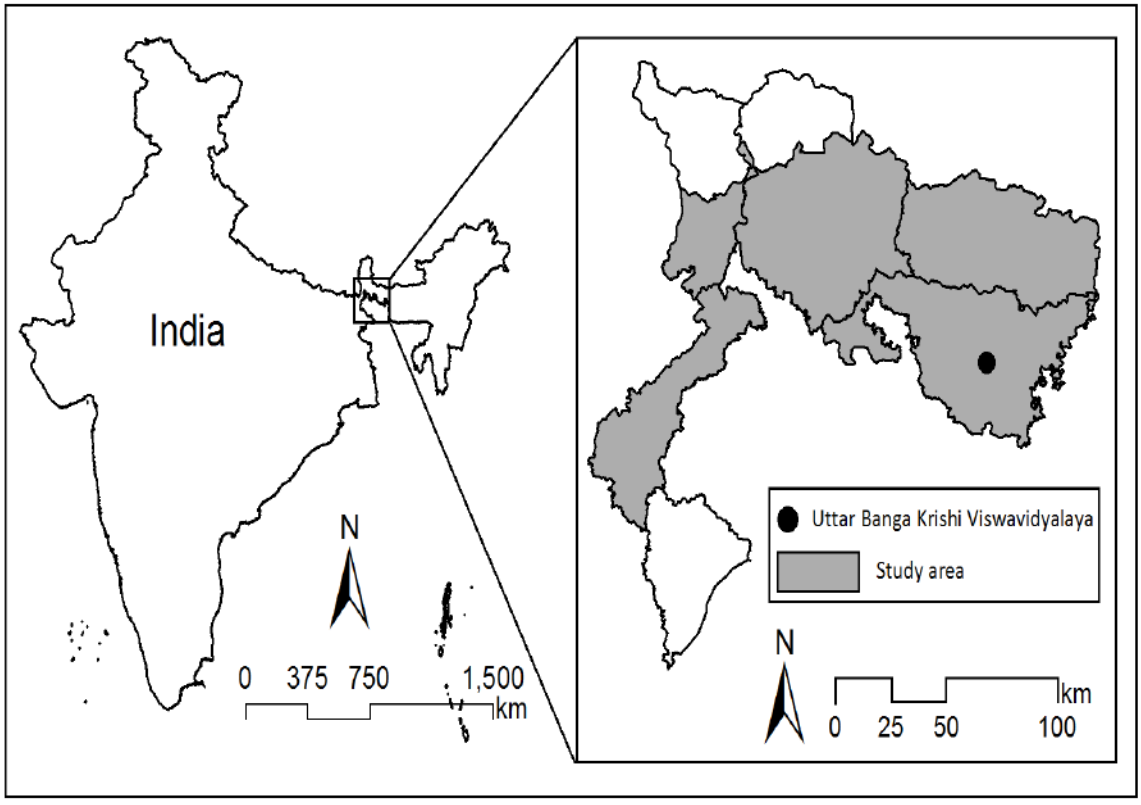


**Figure 1: Geographical Area of Terai Agro-Climatic Zone of West Bengal**

## 2. Review of literature on pest infestation and their management

# CROP PROTECTION

## 2.1 Rice

Rice (*Oryza sativa* Linn.) is the staple food for over half of the world's population. The total cultivated area under West Bengal is 5856 thousand ha (2003-04) having the production of 14662 thousand tonnes (Source: Directorate of Agriculture, Evaluation Wing, Govt. of West Bengal). Rice is the most widely grown crop of this zone cultivated both as *Aman* and *Boro* crop. The varieties of rice which are grown in Terai region are GB-1, MTU-1010, Sahabhagi, Parijat, Annada, Lalat, Anjali, Satabdi, Mashuri, MTU-7029, Malsira, Jaldhapa, Ranjana etc.

The pest scenario in this zone is also changing very fastto be commensurate with other parts of the country. The rice leaf folder, *Cnaphalocrocismedinalis* L. which was earlier considered as a minor and sporadic pest of rice in many Asian countries, appears to have become increasingly important with the spread of high yielding rice varieties and the accompanying changes taken place in the cultural practices. Misuse of insecticides and excessive use of nitrogenous fertilizers have been cited as the cause for high leaf folder populations. Earlier Biswas (2006) reported considerable losses to paddy crop due to this pest from this region.

Ghosh*et al*. (2013) while conducting one experiment at the farm of Regional Research Station, Pundibari observed yellow stem borer (*Scirpophagaincertulas*Wlk.),leaf folder (*Cnaphalocrocismedinalis*Guenee), gall midge (*Orseoliaoryzae*Wood-Manson),green leaf hopper (*Nephotettixvirescens/Nephotettixmigropictus*) and paddy bug (*Leptocoryzaacuta*Th.) as the important insect-pests infesting paddy. It wasobserved that dead heart incidence by stemborers ranged from 3.22 to 8.41% in differentcultivars. The lower incidence was noted inlocal cultivars in comparison to check cultivar,SwarnaMasuri (8.41%). Zeerasal varietyharboured minimum incidence (3.22%), whilemaximum on Pusa basmati-1 (6.58%) amonglocal cultivars.

Similarly, leaf folder population wasfound in higher level in check cultivar(11.30%). Among the local and scentedvarieties, maximum leaf folder infestation wasfound in Pusa basmati-1 (10.26%) andminimum in Kanakchur (4.2%).Gall midge infestationranged between 0.0 to 8.2% with no infestationin case of Sitabhog, Radhunipagal,Chinnisakkar and Zeerasal. Higherinfestation was recorded in check cultivar(8.2%) but among the local cultivars, Pusabasmati registered maximum infestation(5.6%). More or less similar type of infestation pattern of stem borer, leaf folder and gall midge has been reported by Biswas (2006) from this zone.

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Gandhi bugpopulation ranged from 0.83 to 2.50/5 hillswhere maximum populaton was found in bothPusa basmati-1 and Pusa sougandh-2 (5/5 hills) and minimum in Sitabhog (0.83/5 hills)though the check cultivar harboured mediumpopulation (2.33/5 hills) (Ghosh*et al*, 2013).These findings areat par with the findings of Satpathi*et al.* (2005)in West Bengal where they reported 7.2 ofGandhi bug/10 hills. Green leaf hopperspopulation ranged from 1.33 to 6.33/5 hills.Maximum population was found in checkcultivar (6.33/5 hills) followed by Pusa Basmati-1 (5.5/5 hills), while minimum population wasfound in Sitabhog (1.33/5 hills).

Studies on natural parasitization of pests in the rice based cropping system has been carried out and the primary parasitoid *Cotesiaruficrus* (Haliday) on green semilooper, *Narangaaenescens* Moore along with two hyperparasitoids*Trichomalopsisapanteloctena* (Crawford) and *Mesochorus* sp. has been recorded for the first time from this region(Pal and Gupta, 2017). Seven species of sucking bugs were recorded on the earheads of paddy during surveys conducted from 2002-04 at Uttar BangaKrishiViswavidyalaya, Pundibari, Cooch Behar. Among them the population of *Leptocorisaoratorius* (Fabr.) was high and that of *Menidahistrio* (Fabr.) and *Eusarcocorisguttifer* Th. was moderate. Other bugs were recorded in lower proportion (Pal, 2006).

### 2.2 Maize

Maize area under the terai agro-climatic zone is increasing steadily. The maize is infested by a number of pests under this zone. Amongst the insect pests, the aphid *Rhopalosiphummaidis*(Fitch.) has been recorded as a major pest of maize under terai agro climatic conditions (Pal and Bandyopadhyay, 2005b). Other insect pest invading maize included stem borer, *Chilopartellus* (Swinhoe), gram pod borer, *Heliothisarmigera*Hubnerand leaf roller, *Marasmiatrapezalis* (Guenee).

In spite of harbouring relatively higher aphid population the crop sown on 1$^{st}$ March produced the highest grain yield. On the other hand the crop sown on 1$^{st}$ April produced the lowest grain yield though it harboured relatively lower aphid population under terai region of West Bengal. Amongst the different varieties HIM-129 performed best with respect to grain yield though it harboured relatively higher population of aphid. In spite of harbouring lower aphid population VL-42 was found to produce lower grain yield (Pal and Bandyopadhyay, 2005a).

An experiment was conducted at the University Research Farm of Uttar BangaKrishiViswavidyalaya, Pundibari, Cooch Behar to study the reaction of fourteen maize germplasm against the stem borer, *Chilopartellus* (Swinhoe) and the aphid,

*Rhopalosiphummaidis* (Fitch.). The germplasm reacted differentially against these two pests. The varieties viz., VL-88, HIM-129, JM-8, RCM-1-1 and KH-517 had no infestation of stem borer while the variety, FH-3477 showed more infestation. The varieties *viz*., VL-Popcorn and KH-517 were categorized as resistant to the aphid. On the other hand the varieties, viz., HIM-129, RCM-1-2 were found comparatively more susceptible to the aphid (Pal and Bandyopadhyay, 2006).

**2.3 Mustard**

Mustard is the most widely used oilseed crop in the terai region of West Bengal. In this region it is cultivated during the rabi season. The mustard crop was invaded by fourteen insect pests. Among them the aphid, *Lipaphiserysimi*Kalt.,was found as the most dominant and categorized as the major pest. Six species of ladybird beetles, syrphid flies and spiders were recorded as predators of mustard aphid. The flea beetle and diamond back moth were more abundant during pod development stage. On the other hand the sawfly activity was mostly found during the seedling stage of the crop. The natural enemies of mustard aphid appeared much late. Their population increased gradually with the gradual increase in aphid population. The natural enemies exhibited their dependence on aphid population (Choudhury and Pal, 2006).

The incidence of aphid at the farm of Uttar BangaKrishiViswavidyalaya, Pundibari, Cooch Behar commenced from 52$^{nd}$ to2$^{nd}$ standard week with a very low population levels on all the cultivars. The aphid (*Lipaphiserysimi*)population attained peak level from 7$^{th}$ to 9$^{th}$ standard week.Except for a few instancesthe weather parameters showed low order of associations with aphid population. Thus, the ecologicalfactors exhibited little impact on the population build up of mustard aphid. The degree of infestationand the rates of population change of the aphids on different *Brassica* cultivars seem to be governedby varietal characteristics of different germplasms. *Brassica campestris*varieties as a group harbouredrelatively higher populations of the aphid than *Brassica juncea*varieties (Choudhury and Pal, 2009).

The flea beetle was quite active during the month of December infesting the early vegetative stage, but later decreased significantly probably due to the cooler temperature of January as well as hardening of leaf tissues. Later on with the initiation of pod formation and rising of temperature population increased gradually and reached the peak during 4$^{th}$ week of February (Choudhury and Pal, 2005a).

A study was undertaken to find out the suitable variety(s) against insect pests attack aswell as incidence of natural enemies and their effect on yield on three groups of *Brassica*

varietiesin Terai agro-ecological conditions of West Bengal. Among the different insects the importantones were aphid, flea beetle, diamond back moth and saw fly. Natural enemies include lady beetle,syrphid and spider. Contrast analysis revealed that all the pest, natural enemy population andyield varied significantly among the three groups of *Brassica* under consideration. In Terai Zoneof West Bengal, Bhagirathi (Indian mustard variety) showed medium insect-pest reaction as wellas moderate natural enemy population and provided maximum yield (736 kg/ha) and considered tobe the best fitted variety. This variety can replace the Benoy (B9) variety which enjoys the largestarea in this zone, in order to make the cultivation more remunerative in this zone(Ghosh and Chaudhuri, 2015).

An insecticidal trial was conducted at Uttar BangaKrishiViswavidyalaya, Pudibari, Cooch Behar with thiamethoxam, acephate, dimethoate, endosulfan, cypermethrin and azadirachtin to find out the efficacy against mustard aphid, *Lipaphiserysimi*Kalt., which is the most important insect pest under terai zone. One day after spraying thiamethoxam 0.003% was found to be most effective with 20.33 aphids/10 cm apical twig/plant against the highest aphid incidence of 87.00 aphids/10 cm apical twig/plant in the control. The insecticides namely thiamethoxam, acephate and dimethoate showed their residual efficacy upto 10 days after spraying. All the insecticides gave higher yield compared to control. The highest yield was obtained by acephate followed by thiamethoxam, dimethoate, azadirachtin, endosulfan and cypermethrin (Choudhury and Pal, 2005b).

**2.4 Jute**

Jute is the most important cash crop of the zone grown during the pre-kharif to kharif season. The area under under jute cultivation is decreasing day by day due to uncertainty of jute prices and choice before the farmers to grow some other more remunerative crops. Survey work was conducted at research field at UBKV and other two villages viz., village - Dharmobarakutti, G.P. Dhandinguri and village - Chandanchura, G.P. Madhupur to study the pest problems of jute. The yellow mite, *Polyphagotarsonemuslatus* (Banks) and the semilooper, *Anomissabulifera*Guenee has been found as the major pest of jute in this zone.The yellow mite infestation (no. of mite/$cm^2$ area of second unfold leaf) was maximum at 55 DAS with 25.62 and 24.89, at UBKV Research plot and at village Dharmobarakutti, respectively. In case of village Chandanchura, the highest infestation of yellow mite was observed at early stage of crop growth *i.e*. 42 DAS with25.25 mites/$cm^2$ of second unfold leaf. The highest infestation of semilooper was noticed at village Chandanchura with more than twenty percent of infestation at 55 DAS and minimum infestation was observed at village Dharmobarakutti, with 7.69 % at 55 DAS (Pal *et al*., 2015).

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Earlier, Senapati and Ghose (1992) studied the life history, composition and distribution of the yellow and red spider mite on jute leaves under terai ecological conditions of West Bengal. In a field experiments in 1988-89, monocrotophos, endosulfan and quinalphos at 0.05% and chlorpyrifos at 0.04% controlled *Diacrisia obliqua* [*Spilarctia obliqua*] and *Polyphagotarsonemus latus* on jute (Senapati and Ghosh, 1994).

### 2.5 Vegetables

The area and production scenario of different vegetables in West Bengal as per Horticulture Statistics Division,Department of Agriculture,Cooperation and Farmers Welfare, Government of India showed that in 2014-15, it was 2985.40thousand tones for brinja in l161.9 thousand ha; 2207.20thousandtonnes of cabbage in 78.6thousand ha; 1890.0 thousandtonnes of cauliflower in 74.0 thousand ha; 882.40thousandtonnes of okra in 75.5 thousand ha and 1149.60 thousandtones of tomato in 56.90 thousand ha; in 1387.20 thousand ha area under vegetable cultivation in West Bengal with production of 26354.60 thousand tones.

One of the major constraintsidentified in vegetable production is the increasing incidence of insectpests, diseases and nematodes, sometimes resulting in substantialyield losses. Despite considerable increase in the productivity through introduction of hybrid cultivars, a wide gap exists between the potential yield and the yield realized at the farmer´s field, which is largely due to a number of biotic and abiotic stresses to which cabbage crop is exposed.

**Brinjal:**

Brinjal, eggplant, is one of the most common vegetable crops grown in India and other parts of the world. The field experiment conducted in terai region ofWest Bengal, India during 1996-98 (Ghosh and Senapati, 2001) showed that brinjal crop was infested byAphid (*Aphis gossypiiI)*, Jassid (*Amrascabiguttulabiguttula*), white fly (*BemisiatabaciI)*, Thrips (*ThripstabaciI),*epilachna beetle (*Henosepilachnavigintioctopunctata [Epilachnavigintioctopunctata]*), fruit *borer*(*Leucinodesorbonalis*) and flea beetle.Ghosh (1999) and Ghosh and Senapati (2009) reported that in terai region of West Bengal, *Leucinodesorbonalis* is the key pest infesting eggplant and pest was found to be most active during summer and the rainy season, particularly during May–August, and caused 49.5–81.0% damage to fruits. Peak infestation (81.0% fruit damage) was noticed in the first week of June (22nd standard week), when the mean temperature, mean relative humidity and weekly rainfall were 27.8°C, 79.2% and 81.2 mm respectively. The pest became less active during winter months particularly in December–January. Epilachna beetle (*Henosepilachnavigintioctopunctata*Fabr.) was foundactive from April to middle of October

and highest populationwas recordedduring middle of September (8.14beetle/plant) (Ghosh and Senapati, 2001).The higher level of thrips population was maintained from March to November, while for white fly it was during August and October (Ghosh, 1999).Among different cultivars, PK-123 and Pant were the least susceptible to *L. orbonalis*, the key pest of auberginein terai region of West Bengal (Ghosh and Senapati, 2001).

**Cabbage:**

Among various vegetables, cabbageis mostcommon and extensively grown all over the country. Besides being a rich source of vitamins and minerals, it occupies an important place in the food basket of Indian consumers.In terai region of West Bengal Chaudhuri*et al*. (2001) observed the incidence of insect-pests of cabbage and reported that the populations of aphid (*Lipaphiserysimi*) was observed during 3$^{rd}$week of March, flea beetle (*Phyllotretabrassicae*) in last week of March, cabbage butterfly (*Pierisbrassicae*) in 2$^{nd}$week of March, cabbage leaf Webber (*Crocidolomiabinotalis*) in 1$^{st}$ week of March, dimond back moth (*Plutellaxylostella*) in last week of March reached maximum level on spring crop. They further reported that crop raised during winter needs no protection measure because of low level of pest incidence but spring crop needs protection measures during middle of March to late April for better harvest. Das and Chaudhuri (2007) reported that In Terai region of West Bengal the Diamond back moth (*Plutellaxylostella*) appeared on cabbage during February and the infestation continued up to May in an overlapping manner, within and over the generations. During February-March the prevailing climatic conditions did not only the favourmultiplication of *Plutella* population but also activated its parasitoids.Among the diseases, Alternaria leaf spot caused by *Alternaria* sp. (*A.brassicae* and *A. brassicicola*) has been reported from all the continents of the world and is one among the common diseases of cabbage. Alternaria blight is one of the most dominant one that causesaverage yield loss in the range of 32-57% (Conn and Tewari, 1990). Abhijit (2017) reported that biocontrol agents *viz*., *Trichodermaharzianum* (UBT18) and *Pseudomonasfluorescence* (VPF-1)enhanced the activities of defense related enzymes and protein content against Alternaria leaf spot in cabbage.

**Cauliflower:**

Cauliflower (*Brassicaoleracea*var.*botrytis* L.) is one of the most widely cultivated colecropin India.Cauliflower varieties are highly sensitive to soil and environmental variation which significantly affect the crop growth and curd yield.

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In teari region of West Bengal maximum population of aphids, *Lipaphiserysimi* (33.36 aphids/leaf), and flea beetles, *Phyllotretacruciferae* (0.78 flea beetles/plant), were found to harbour cauliflower during the last week of December (25 to 31 December) and 3rd week of December (18 to 24 December), respectively (Ghosh*et al*., 2000).

**Tomato:**

Tomato (*Lycopersiconesculentum*), is an important vegetable crop inIndia. In terai region of West Bengal tomato crop is attacked by aphid, whitefly, jassid, leaf miner and fruit borer (Chaudhuri*etal*., 2003).Higher level of leaf miner (*Liriomyzatrifolii*) infestation on tomato in terai region of West Bengal was maintained from late March to late May (Chaudhuri and Senapati, 2004). The white fly population reached the highest level (1.68/plant)during middle of February and high level was maintained from mid February to mid March whentemperature, relative humidity, sunshine hr/dayand rainfall were ranged from 17.07-22.13°C,65.29-72.78%, 7.79-8.98hr/day and 5mm respectively (Chaudhuri*et al*., 2001).Subba (2013) found higher population level of whitefly during 2$^{nd}$ week of March to 3$^{rd}$week of March.The important pest of tomato the fruit borer damage was observed during 6-20$^{th}$ SW *i.e* from mid-February to mid-May (Chaudhuri*et al*., 2000).

**Okra:**

Okra (*Abelmoschusesculentus* L.) is an annual vegetable crop, grown well under agro-ecological conditions of terai region. Warm humid climate, high rainfall, and loam to sandy loam soil very much favour okra cultivation in a commercial scale round the year except short spell of cold winter associated with frost for about 2 months.In okra all the important and major pests are either oligophagous or polyphagous and most of the alternate hosts are vegetables grown as proceeding or succeeding crop or in vicinity to okra fields. All these favour pests carry over and pest populations increase rapidly with raising of the crop.

In terai region the major insect-pest of okra was jassid and fruit borer. The mean jassid population was highest on pre-kharifand lowest in kharif. And the mean infestation level of fruit borer was highest in kharif seasonand least in pre-kharif.Both the pest attained ETL level at 15 and 16$^{th}$SW persisted at higher level till 17$^{th}$-20$^{th}$ SW in pre-kharif; in kharif the major pest was fruit borer and the infestation remained at peak in 35-40SW. In post-kharifpeak fruit borer infestation level was maintained between 42 to 45 SW (Subba, 2017).

## 3. Review of literature on incidence and severity of major diseases and their management

# CROP PROTECTION

## 3.1 Rice

West Bengal is the richest reservoir of rice (*Oryza sativa* Linn.) bio-diversity and the rice bowl of the country. The ecotypes of rice, spontaneously evolved in the state, are so diverse and different that Scientists at one time coined them as Oryza sativa var. benghalensis (Chatterjee et al., 2008). The total cultivated area under West Bengal is 5856 thousand ha (2003-04) having the production of 14662 thousand tonnes (Source: Directorate of Agriculture, Evaluation Wing, Govt. of West Bengal). Rice is the most widely grown crop of this zone cultivated both as *Aman* and *Boro* crop. Varieties of rice crop grown in West Bengal are Sabita, Purnendu, Amulya, Bhudev, Nalini, Bhagirathi, Ambika, Mahananda, Matangini, Saraswati, Sudhir, Sunil, Hanseshwari, Shatabdi, Khitish, Gotra Bidhan 1, Lakshmi (CNM 6), PNR 546, CNM 25. Varieties which are grown in Terai region are Annanda, GB-1, MTU-1010, Parijat, Satabdi, Mashuri, MTU-7029, Malsira, Jaldhapa, Ranjana, Niranjana etc. (Das, 2016).

Rice (Oryza sativa L.) suffers from a number of fungal and bacterial diseases and many of them occur at times in fairly severe form and cause substantial loss to the crop yield. Major fungal disease are sheath blight, blast, brown spot, false smut and bacterial diseases are bacteria leaf blight and bacterial leaf streak.

Among the major fungal diseases of rice, brown spot occupies not only an important position, but also historical interest. The disease is prevalent throughout the rice growing tracts of the world. It is found to be pendemic in heavy rainfall areas viz. the Himalayas, Assam, Malabar coast and West Bengal.

Rice blast is one of the most important diseases of rice, caused by the fungus *Magnaporthe oryzae* B. C. Couch (Couch and Kohn 2002). One of the main limitations in production is rice blast disease caused by the fungus *Magnaporthe oryzae.* Annual rice losses caused by this fungus during 90's had been estimated at 35% of the worldwide production (Oerke and Dehne 2004).

Use of *Trichoderma* spp. in heavy metal contaminated ecosystem for bioremediation and the resultant effect of less uptake and consequent low residual toxicity of metals in rice plant.

## 3.2 Wheat:

The second most importance food crop of the country is Wheat. The area under wheat production has steadily gone up. In 2013-14 India ranked second in wheat production after china in the world for the wheat production of 95.85 million tones, and wheat area has

increased from 12.8 million-ha in 1966-67 to 29.8 million-ha in 2015-16, at the same time productivity and production has been increased by 263% and 711% respectively, and India produced 2.95 ton wheat in a hectare against 5.34 ton by china in 2015-16 (Kumar, *et al.*, 2016). For feeding purpose of the increasing population of the India, country need to produce 100 million tons of wheat with in 2030, that is a major challenge under changing climatic scenario.

With the extension of wheat cultivation in the warmer and humid region of North Eastern Plain Zone after green revolution many new diseases and pest problems were also encountered that created significant yield loss. Different types of disease found in North Eastern plain zone, like foliar blight, rust, loose smut etc. Foliar blight is complex of many pathogens, among these *Bipolaris sorokiniana* is a most destructive disease, which attack wheat plant at most crucial growth stage (Chourasia *et al*. 2000).

In warm and humid regions of the world (Kumar *et al*., 2002) *B. sorokiniana* (syn. *Helminthosporium sativum*, teleomorph *Cochliobolus sativus*), is a well-known cause of spot blotch of wheat (*Triticum aestivum*) and barley (*Hordeum vulgare*). *Bipolaris sorokiniana* a notorious wheat fungal pathogen. Yield losses due to spot blotch disease in wheat are reported to range from 15.5% to 100% under severe conditions of infection (Mehta, 1993). . Grain yield loss due to spot blotch in South Asia ranged from 04-38 per cent and 25- 43 per cent in the year 2004 and 2005, respectively (Sharma and Duvellier, 2006).

Leaf blight affected samples collected from different parts of terai agro-climatic zones of West Bengal shows that a number of pathogens viz. *Bipolaris sorokiniana*, *Alternaria triticina*, *Curvularia lunata*, *Drechslera gigantea*, *Alternaria alternata*, *Pyrenophora tritici-repentis* were associated with the foliar blight symptoms, of which *B. sorokiniana*, *A. triticina*, *D. gigantea* and *P. tritici-repentis* were pathogenic.

Relative dominance of foliar blight pathogens in different stages of wheat is measured. *A. triticina* dominated in the very early stages of crop growth and a shift was noted at stage 47 i.e. during flag leaf sheath opening when *B. sorokiniana* became the dominant pathogen. At the latter stages of crop growth, *D. gigantea* also simultaneously appears along with *B. sorokiniana*.

Chowdhury, *et al.* (2014) found that foliar blight is the major biotic constraint of wheat in rice wheat system of eastern Gangetic plains. Singh, *et al.* (2014) observed that ooptimum growth stage of wheat and triticale for evaluation of resistance against spot blotch.

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The yield loss due to foliar blight in this agro-climatic zone is estimated. The extent of yield loss was ranged from 4.5 percent to 33.3 percent.

Cultural and physiological variability among the isolates of *Bipolaris sorokiniana* indicates a wide variation. Thirteen isolates of *Bipolaris sorokiniana* have been characterized. Three linkage groups (2D, 7B, 7D) in population Sonalika/BH 1146 and four linkage groups (1B, 2B, 2D, 7D) have been detected in population Kanchan/ Chirya 1

Epidemiology of spot blotch in wheat was worked out which indicated that delayed sowing changes the physiology and microclimate of the crop. A positive relationship with canopy temperature and negative relationship with stay green property is found. Linear correlation between spot blotch severity with maximum temperature, minimum temperature, sunshine hours and evapo-transpiration has established.

More than 2000 genotype collected from National and International sources have been screened against spot blotch of wheat and few genotypes show highly resistant against the disease. The biochemical parameters viz, POX, PPO, SOD, Phenols have been estimated in resistant and susceptible genotype

Singh, *et al.* (2014) reported that phenotypic and marker aided identification of donors for spot blotch resistance in wheat.

The researches on deciphering phytohormone signalling in modulation of resistance to spot blotch disease of wheat have been carried out.

Integrated disease management against foliar blight has been worked out.

Foliar spray with Hexaconazole @ 0.1% first at disease appearance and then 2 times at 20 days interval is the best treatment for the management of leaf spot disease of ginger.

Wheat Entry no. 6746 was found to be the most resistant germplasm against spot blotch disease with lowest AUDPC both in non-protected and protected conditions. UBPF 6 (*Pseudomonas fluorescence* collected from brinjal rhizosphere of UBKV farm, Pundibari) induced the highest resistance in the wheat plants. Seed treatment with talc formulation of UBPF 6 @ 5 g/kg of seeds followed by spraying with the same @ 10 g/litre of water at 55 days after sowing (DAS) and 65 DAS was found to be the best treatment as it recorded the lowest disease and highest yield of 4.69 t/ha. Kumar, *et al.* (2017) Evaluated 19,460 numbers of Wheat Accessions Conserved in the Indian National Genebank to Identify New Sources of Resistance to Rust and Spot Blotch Diseases . Sahu, Ranabir; Sharaff, Murali; Pradhan, Maitree; Sethi, Avinash; Bandopadhyay,

Mishra, *et al.* (2016) also reported that elucidation of defense-related signaling responses to spot blotch infection in bread wheat (Triticum aestivum L.). Wheat Entry no. 6746 was found

to be the most resistant germplasm against spot blotch disease with lowest AUDPC both in non-protected and protected conditions. UBPF 6 (*Pseudomonas fluorescence* collected from brinjal rhizosphere of UBKV farm, Pundibari) induced the highest resistance in the wheat plants. Seed treatment with talc formulation of UBPF 6 @ 5 g/kg of seeds followed by spraying with the same @ 10 g/litre of water at 55 days after sowing (DAS) and 65 DAS was found to be the best treatment as it recorded the lowest disease and highest yield of 4.69 t/ha (Anonymous, 2016).

**3.3 Maize:**

Maize area under the terai agro-climatic zone is increasing steadily. The maize is infested by a number of pests under this zone. Amongst the insect pests, the aphid *Rhopalosiphummaidis*(Fitch.) has been recorded as a major pest of maize under terai agro climatic conditions (Pal and Bandyopadhyay, 2005b). Other insect pest invading maize included stem borer, *Chilopartellus* (Swinhoe), gram pod borer, *Heliothisarmigera*Hubnerand leaf roller, *Marasmiatrapezalis* (Guenee).

**3.4 Mustard**

Rapeseed-mustard (Brassica sp.) is a major group of oilseed crop of the world being grown in 53 countries across the six continents, with India being the third largest producer after China and Canada (FAO 2009). It is also important rabi oilseed crop of West Bengal cultivated in about 410.793 thousand ha with total production of about 419.58 thousand tones and average productivity of 1021 kg/ha (Anon 2011).

Varieties of mustard are Pusa Agrani (SEJ-2), Pusa Karishma (LES-39), Pusa Mahak (JD-6), Pusa Mustard 21 (LES 1 27), Pusa Vijay (NPJ-93), Pusa Mustard 22 (LET -17), Pusa Mustard-24 (LET-18), Pusa Tarak (EJ-13), NPJ-112 (Pusa Mustard 25), Pusa Mustard 26(NPJ-113), Pusa Mustard 27 (EJ-17), Pusa Mustard 28 (NPJ- 124) etc. In Terai region varieties like Jhumka, Baruna, Sita, Panchali, Binoy, Bhagirathi etc are mostly grown (Das, 2016).

Among several diseases, four diseases viz; Alternaria blight (Alternaria brassicae), white rust + downy mildew complex (Albugo candida + Hyaloperonospora parasitica), Sclerotinia stem rot (Sclerotinia sclerotiorum) and powdery mildew (Erysiphe cruciferarum) are of great economic importance, whereas among several insect pests, mustard aphid (Lipaphis erysimi) is the key pest and five others viz, sawfly (Athalia lugens proxima), painted bug (Bagrada hilaris), leaf miner (Chromatomyia horticola), cabbage butterfly (Pieris

brassicae) and Bihar hairy caterpillar (Spilosoma obliqua) are assumed to be of regional and sporadic importance (Bakhetia et al., 2002).

*Alternaria* blight caused by *Alternaria brassicae* (Berk.) Sacc. has been reported as one of the most serious threat to the production of rapeseed and mustard in West Bengal situation which is reflected in various yield attributing factors eventually affecting the yield. Variety Kalyan gave maximum yield (1544.75 kg/ha) while, it was minimum in case of variety Agrani (786.65 kg/ha). The observations also show that Alternaria has a direct effect on yield of rapeseed and mustard which was revealed by the fact that moderately resistant varieties had more yield (w.r.t. yield and other yield attributing factors) as compared to highly susceptible varieties (Mamgain, 2017).

Banerjee *et al.*(2010) reported that *Alternaria* blight [*A. brassicicola* (Schw.)] and downy mildew [*Peronospora parasitica*(Pers.) Kuntze] are the major diseases in lower Gangetic plains of India. As the rate of disease increase are dependent on weather factors, weather-based forewarning system may enable to guide farmers to take protection measures timely. The paper aims at to find the effect of weather on alternaria blight and downy mildew infestations. The weather data were compared with Percent Disease Index and the prevailing weather condition during peak disease intensity has been sorted out. It was observed that an increasing trend of last seven days average minimum temperature and relative humidity indicates more Alternaria blight and downy mildew infestation.

### 3.5 Jute

Jute is the most important cash crop of the zone grown during the pre-kharif to kharif season. The area under under jute cultivation is decreasing day by day due to uncertainty of jute prices and choice before the farmers to grow some other more remunerative crops.

The incidence of stem rot in jute sown from March to June indicates early sown crop to be most susceptible to stem rot with 29.83% disease incidence. Crops sown later to March suffered less. Jute crop sown in the first week of April had lesser stem rot incidence than earlier sown crops and maximum fibre yield. In later crops although disease incidence was less, the yield also reduced. Among the new fungicides, application of Tebuconazole 25.9 EC @ 1ml/l (0.1 % a.i.) as seed treatment and foliar spray at 45 DAS was most effective against stem rot of jute.

### 3.6 Vegetables

Vegetables are vital sources of minerals, vitamins and dietary fibres and thus play an important role in human nutrition in supplying adequate quantity of free radicals, anti-oxidants

and micro-nutrients. The area and production scenario of different vegetables in West Bengal as per Horticulture Statistics Division,Department of Agriculture,Cooperation and Farmers Welfare, Government of India showed that in 2014-15, it was 2985.40thousand tones for brinja in l161.9 thousand ha; 2207.20thousandtonnes of cabbage in 78.6thousand ha; 1890.0 thousandtonnes of cauliflower in 74.0 thousand ha; 882.40thousandtonnes of okra in 75.5 thousand ha and 1149.60 thousandtones of tomato in 56.90 thousand ha; in 1387.20 thousand ha area under vegetable cultivation in West Bengal with production of 26354.60 thousand tones.

One of the major constraints identified in vegetable production is the increasing incidence of insect pests, diseases and nematodes, sometimes resulting in substantial yield losses. Despite considerable increase in the productivity through introduction of hybrid cultivars, a wide gap exists between the potential yield and the yield realized at the farmer´s field, which is largely due to a number of biotic and abiotic stresses to which cabbage crop is exposed.

**A. Potato:**

Late blight caused by *Phytophthora infestans* (Mont.) de Bary is one of the most dreaded diseases of potato worldwide, including India and cause significant loss in production. The causal organism of this disease came to India with imported seed potatoes from Europe.It was first recorded in india for the first time between 1870-1880 in the Nilgiri hills and sread rapidly to north Indian hills. From hills the disease gradually spread to Indo-Gangetic plains. Under tropical plains, it was first observed in 1889-1900 in Hoogly district of West Bengal. Subsequently, it was reported from other parts of the country.The pathogen is highly variable and adapt to the newly bred varieties and fungicides. India is the second largest producer of potato in the world after China and both the countries put together contribute nearly one third of the global potato production (Scott and Suarez, 2012).

Some cultivated variety of potato crop are Kufri Kisan, Kufri Kuber, Kufri Kumar, Kufri Kundan, Kufri Red, Kufri Safed, Kufri Neela, Kufri Sindhuri, Kufri Alankar, Kufri Chamatkar, Kufri Chandramukhi, Kufri Jeevan, Kufri Jyoti, Kufri Khasigaro, Kufri Naveen, Kufri Neelamani, Kufri Sheetman, Kufri Muthu etc. In 4 Terai region Khufri Jyoti, Pimpernel, Detia (Red and white skin), Solanum tuberosum sub. sp. andijena, Pokhraj, Kufri Chipsona 3, Kufri Chipsona 4, Kufri Chipsona 5 etc. (Das, 2016).

The late blight attack and kills the tops of the potato plant and invades the tubers, causing either a dry or a wet rot. It is the most destructive of all the potato diseases when conditions are favorable for its rapid development. The fungus causing this disease,

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Phytophthora infestans, is basically a cold climate pathogen but has tremendous capacity to adopt to environments thus becoming widespread in almost all environments (temperate as well as sub-tropical) which support potato production.

Today the disease is a recurring feature in plains of West Bengal. It occurs in mild to moderate form every year but assumes severe form and develop epidemic only in occasions. Yield losses in the plains have been estimated around 10-75% (Dutt, 1979).

Chakraborty and Banerjee (2016) reported that prophylactic spray with mancozeb @ 0.2% followed by fenamidone + manozeb @ 0.3% as 2nd spray at the onset of the disease followed by mancozeb @ 0.2% as 3rd spray seven days after application of the 2nd spray followed by one more spray with fenamidone+mancozeb @ 0.3% as 4th spray seven days after application of 3rd spray exhibited best management of late blight of potato in terms of percent reduction of disease over control which was 83.64 and 84.79% in 2012-13 and 2013-14 crop season, respectively.

Hembram (2016) found that prophylactic spray with mancozeb @ 0.25% followed by Ametoctradin + Dimethomorph @ 0.3% at the onset of the disease and 10 days after 1$^{st}$ application followed by mancozeb @ 0.25% seven days after the last application of systemic fungicide or prophylactic spray with mancozeb @ 0.25% significantly reduce the disease pressure. He also reported that spraying of Cymoxanil + mancozeb @ 0.3% at the onset of the disease and 10 days after 1$^{st}$ application followed by mancozeb @ 0.25% seven days after the last application of systemic fungicide or prophylactic spray with mancozeb @ 0.25% are also very effective.

According to Bandyopadhyay (2015) the highest percent late blight disease reduction in comparison to control was observed in Chlorothalonil 75% WP @ 1750 gm/ha (68.12%) followed by Chlorothalonil 75% WP @ 2500, 1250 and 875 gm/ha in comparison to control respectively and highest number of tuber per plant (6.33 tuber/plant) was recorded by Chlorothalonil 75% WP @ 1750 gm/ha. Lowest yield of 22.67 t/ha and number of tuber plant (3.33/plant) was found in untreated control plot.

**B. Brinjal:**

Brinjal, eggplant, is one of the most common vegetable crops grown in India and other parts of the world. Plant Growth Promoting Microbial inoculation based organic module for vegetable seedling raising approach was formulated for tomato, brinjal, chilli, cabbage, cauliflower, capsicum etc. cultivation under organic farming system in hill and terai agro-ecological region of West Bengal (Bhattacharya, 2016)

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**C. Cabbage:**

Among various vegetables, cabbage is most common and extensively grown all over the country. Besides being a rich source of vitamins and minerals, it occupies an important place in the food basket of Indian consumers. Among the diseases, Alternaria leaf spot caused by *Alternaria* sp. (*A.brassicae* and *A. brassicicola*) has been reported from all the continents of the world and is one among the common diseases of cabbage. Alternaria blight is one of the most dominant one that causesaverage yield loss in the range of 32-57% (Conn and Tewari, 1990). Abhijit (2017) reported that biocontrol agents *viz*., *Trichodermaharzianum* (UBT18) and *Pseudomonasfluorescence* (VPF-1)enhanced the activities of defense related enzymes and protein content against Alternaria leaf spot in cabbage.

Sarkar, *et al.* (2016) reported that Microbial consortium helps on plant growth promotion, biochemical attributes and nutrient uptake of Cabbage (*Brassica oleracea* L. var *capitata*).

According to Bhattacharya, *et al.*(2014) in India, clubroot caused by *Plasmodiophora brassicae* Woronin has been present on cabbage and cauliflower crops (*Brassica oleracea* L. var. *capitata* and *botrytis*) for nearly 80 years in the Eastern Himalayan Darjeeling Hills of West Bengal and South Indian Nilgiri Hills in Tamil Nadu. Since the early 1980s, *P. brassicae* has spread rapidly on the most popular cultivars of cultivated yellow sarson (*Brassica rapa* L. var. *trilocularis* (Roxb.) Kitam.) and Indian mustard (*Brassica juncea* L.) grown in the red and lateritic soils (Alfisols) and the Terai regions situated in the Himalayan foothills of the northern part of West Bengal State. Soils of both regions are acidic in nature (pH 5.3–6.7).

**D. Cauliflower:**

Cauliflower (*Brassicaoleracea*var.*botrytis* L.) is one of the most widely cultivated colecropin India.Cauliflower varieties are highly sensitive to soil and environmental variation which significantly affect the crop growth and curd yield. Lama, *et al.* (2012) reported that seed encapsulation with *Trichoderma harzianum* on growth promotion and development of induced biochemical resistance in cauliflower seedling. Roy *et al.* (2014) observed that application of pellet based formulation of *Pseudomonas fluorescens* enhance the seedling health of cauliflower.

**E. Tomato:**

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Tomato (*Lycopersiconesculentum*), is an important vegetable crop inIndia. India is the second largest producer of vegetables in the world and accounts for about 11.4 % of the world's production of vegetables.

In terai region of West Bengal tomato crop is attacked by aphid, whitefly, jassid, leaf miner and fruit borer (Chaudhuri*etal*., 2003).

Among all the diseases, *Rhizoctonia solani* induced damping off is one of the most important soil borne diseases of tomato causing severe losses under favourable environmental condition at nursery bed. Since it is difficult to achieve control through host resistance or fungicides because of soil borne nature of the pathogen and wide host range, induced systemic resistance through the use of biotic elicitors may be effective alternative in minimizing the incidence of the disease.

Dutta (2005) reported that out of 204 rhizospheric isolates obtained from mungbean, rice, banana, chilli and from vermicompost, 9 isolates showed showed potential antagonistic activity against four soil borne plant pathogens (*Rhizoctonia solani, Macrophomina phaseolina, Sclerotinia sclerotiorum and Sclerotium rolfsii*). The population of fluorescent *psedomonads* was found to be maximum in vermicompost and mungbean rhizosphere supported population of rhizospheric bacteria. Seed treatment with native biocontrol consortium exhibited enhanced level of protection as compared to native individual antagonistic rhizobacteria against both pre- and post-emergence damping off of tomato. The population of antagonistic rhizobacteria was increased upto 14 days after seed treatment but enhanced level of population of introduced native antagonistic bacteria were observed upto 3 weeks of seed treatment. The native isolate was able to colonize on non-host crop (Dutta, 2005).

Barik (2006) reported that approximately, 10-38% of bacterial wilt of tomato incidence was recorded into different locations of Cooch Behar district under different cropping system and Higher level of *R. solanacearum* population was observed in different tomato based cropping system, but cabbage followed by tomato has somehow lower population of *Ralstonia solanacearum.* Only ginger isolate (Kamp Gin-1) of Kalimpong, belonging to biovar-III and *Ralstonia solanacearum* isolates (tomato, chilli, potato, brinjal) from Cooch Behar region were found to be biovar-II.

He also observed that Among the various soil amendments bleaching powder and lime was found to be highly effective in reduction of bacterial wilt incidence and About 9.5 fold decrease in *Ralstonia solanacearum* was observed in the treatment where seedlings were treated with bio-agents consortium (Bpf-1, *Paecilomyces*, Azo-5, AcPSM-1) and the soil were amended with lime + bleaching powder + neem cake + vermicompost.

### F. Okra:

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Okra (*Abelmoschusesculentus* L.) is an annual vegetable crop, grown well under agro-ecological conditions of terai region. Warm humid climate, high rainfall, and loam to sandy loam soil very much favour okra cultivation in a commercial scale round the year except short spell of cold winter associated with frost for about 2 months.In okra all the important and major pests are either oligophagous or polyphagous and most of the alternate hosts are vegetables grown as proceeding or succeeding crop or in vicinity to okra fields. All these favour pests carry over and pest populations increase rapidly with raising of the crop.

In terai region the major insect-pest of okra was jassid and fruit borer. The mean jassid population was highest on pre-kharifand lowest in kharif. And the mean infestation level of fruit borer was highest in kharif seasonand least in pre-kharif.Both the pest attained ETL level at 15 and 16$^{th}$SW persisted at higher level till 17$^{th}$-20$^{th}$ SW in pre-kharif; in kharif the major pest was fruit borer and the infestation remained at peak in 35-40SW. In post-kharifpeak fruit borer infestation level was maintained between 42 to 45 SW (Subba, 2017).

Important diseases of okra are Damping off, Fusarium wilt, Cercospora Leafspot, powdery mildew, Yellow vein mosaic and Root knot nematodes. Among them, In India, two species of *Cercospora* produce leaf spots in bhendi. C. *Malayensis* causes brown, irregular spots and C. *abelmoschi* causes sooty black, angular spots. Both the leaf spots cause severe defoliation and are common during humid seasons. The fungi survive through conidia and stomata on crop residue in soil.

Fursarium wilt, a serious disease, found wherever okra is grown intensively. The okra *Fusarium* also infects cotton and certain other plants in the sp. Malvaceae family.

### G. Chili:

Chilli (*Capsicum annuum* L.) also known as red pepper is the highest consumed spice in the world, belongs to the family Solanaceae and genus Capsicum. It is an important constituent of many foods, adding flavor, colour, vitamins, pungency and therefore indispensable to the world food industries. Chilli is one of the major cash crops in India and our country is rated to be the second largest exporter in the world.

The crop is mainly grown for its pungent fruits which are used as green and ripe to impart pungency to food. India is the single largest chilli producer contributing for about 38% followed by China. In country, West Bengal stands 4th in production (100,000 MT) grown in an area of 63.6 lakh ha with productivity 1.57 MT/ha followed by Andhra Pradesh, Tamil Nadu and Karnataka (India stat, 2011-12).

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Major diseases that affect capsicum and chilli crops are Bacterial wilt, Anthracnose, Choaenophora Blight, Cercospora spot, Powdery mildew, Stem rot (Sclerotinium), Sudden wilt, Spotted wilt and other viruses, Tomato yellow leaf curl virus and Tomato root-knot nematodes. Among the different diseases Anthracnose, Choaenophora Blight and Tomato yellow leaf curl virus are most important causing havoc damage to the crops.

A Survey was conducted by Suresh, *et.al.*(2017) in major chilli growing areas of west Bengal for most prevailing diseases in chilli during the year 2015-16. As a result in chilli apart from the anthracnose, Alternaria, Choanephora blight a new disease was observed showing symptoms as dark brown spots on leaf, stem and fruit on chilli (*Capsicum annuum* L.) plants in Basantapur, West Bengal during 2015–2016.

Using microbial inoculants reduction of inorganic fertilizers to the extent of 75% is possible in chilli under terai ecological zone of West Bengal.

Out of 81 rhizospheric isolates obtained from maize, wheat and chilli, 6 numbers of isolates showed potential antagonistic activity against 4 soil-borne plant pathogens (*Rhizoctonia solani, Macrophomina phaseolina, Sclerotinia sclerotiorum* and *Sclerotium rolfsii*). Among the six effective rhizobacterial isolates MPf-1 was found to be the most effective isolate and suppressed the mycelial growth of all the four soil-borne plant pathogenic fungi (mean % growth inhibition 70.3% and mean inhibition zone 18.6 mm) followed by MPf-2 and P-2. Among the rhizobacterial isolates, MPf-1 was most effective in inhibiting sclerotia production of the sclerotia producing soil-borne pathogens (mean inhibition of sclerotia production by 93.33%) followed by P-2 and MPf-2 respectively.

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## List of Rabi-2017-18 Programme under RRSTZ

| Sl. No. | Project Code | Title of the Programme | Associate Scientists |
|---|---|---|---|
| | | Animal Science & Fishery | |
| 1 | RRSTZ/Rabi/17-18/06 | Production performance, egg quality indices and hatchability percent of Khaki Campbell ducks under semi-intensive rearing system at low ambient Temperature in Terai Zone of West Bengal | Dr. Nonigopal Shit<br>Dr. Dilip Kumar Hajra |
| 2 | RRSTZ/Rabi/17-18/09 | Performance trial of different crops with fish under Integrated Farming System Research in the fish farm of RRS, Terai Zone | Prof. Debapriya Sarkar and Dr. Nilanjana Chaudhuri |
| | | Crop Improvement | |
| 3 | RRSTZ/Rabi/17-18/08 | Performance of grafted tomato (Stock: UBB-8Scion: Meghali) for enhancing the resistance against biotic stress | Dr. Hossain Ali Mondal |
| 4 | RRSTZ/Rabi/17-18/05 | Selection of mungbean genotypes for tolerance to water-logging under field condition | Dr. Rupsanatan Mandal |
| | | Crop Production | |
| 5 | RRSTZ/Rabi/17-18/01 | Effect of seed priming on the performances of wheat cultivars under zero tillage | Dr. Partha Sarathi Patra |
| 6 | RRSTZ/Rabi/17-18/12 | Effect of different dates of planting (DOP) on a heavy panicle rice variety 'Maudamani' in Terai zone of West Bengal | Dr. Parthendu Poddar |
| | | Crop Protection | |
| 7 | RRSTZ/Rabi/17-18/03 | Occurrence and Management of Major Fungal Diseases of Tomato under Terai Zone of West Bengal | Dr. Satyajit Hembram |
| 8 | RRTZ/Rabi/17-18/04-01 | Evaluation of different management strategies on the insect-pest complex of cabbage | Dr. Nilanjana Chaudhuri |
| 9 | RRTZ/Rabi/17-18/04-02 | Evaluation of conservation agricultural strategies on wheat, maize and lentil agro-ecosystem | Dr. Nilanjana Chaudhuri |
| 10 | RRSTZ/Rabi/17-18/02 | Evaluation of different pest management modules for the insect pest complex of brinjal | Dr. Suprakash Pal |
| | | Horticulture | |
| 11 | RRSTZ/Rabi/2017-18/07 | Title of the programme: Effect of sowing time and variety on the Growth, yield and quality of bush type vegetable French bean | Dr. Suchand Datta |
| | | Social Science | |
| 12 | RRSTZ/Rabi/17-18/11 | Long Term time series analysis of data on area, production and productivity of oil seed crops and meteorological parameters (Temperature, Rainfall and Sunshine hour) of Terai Agro-climatic zone of West Bengal | Dr.ArunavaGhosh |
| 13 | RRSTZ/Rabi/17-18/10 | Modelling area, production and productivity of rice at Cooch Behar district | Prof. S. Basak |

## ANIMAL SCIENCE AND FISHERIES

**Title of the Programme:** ***Production performance, egg quality indices and hatchability percent of Khaki Campbell ducks under semi-intensive rearing system at low ambient Temperature in Terai Zone of West Bengal***

**Project code:** RRSTZ/Rabi/17-18/06

**Associate Scientist/s:** Dr. Nonigopal Shit & Dr. Dilip Kumar Hajra

**Objectives:**

- ✓ Evaluation of production performance at low ambient temperature
- ✓ Examination of the egg quality attributes
- ✓ Estimation of hatching percent in relation to low ambient temperature

**Materials:**

- ✓ *Study location and animal ethics*
- The proposed programme was conducted in the learning cum experimental duck shed under Integrated Farming System (IFS) model of the university following scientific procedure during the period of October, 2017 to February, 2018. The temperature and humidity recorded during this period varied between 7.5$^{o}$C to 28$^{o}$C and 55% to 76% respectively during the experimental period.
- ✓ *Experimental Design and diets*
- A total thirty khaki Campbell ducks at 16 weeks of age from the same hatch were selected based on the physical conformation for this study. They were divided into three replicates i.e. 10ducks/replicate. The subjects were managed under semi-intensive system under 16h photo-schedules. Apart from the foraging, they were offered low cost feed formulated with local resources and drinking water *ad-libitum*. After complete acclimatization, the experiment was started on 5% duck house egg production.

**Methodology:**

- ✓ ***Production performance:***

a. Body weight:
Body weight of individual duck was recorded at fortnight interval in an electronic weighing balance with 0.01 precision and expressed in gm. Body weight gain (g)

b. Hen day egg production (%)

$$\text{Hen day egg production:} \quad \frac{\text{No. of eggs produced}}{\text{No. of ducks in the house on particular day}} \times 100$$

c. Hen house egg production (%)

$$\text{Hen house egg production:} \quad \frac{\text{No. of eggs produced}}{\text{No. of ducks housed initially}} \times 100$$

✓ ***Measurement of egg quality (external and internal) parameters***

a. Egg weight:

Eggs were collected daily, weighed individually to the nearest mg and recorded daily for 18 weeks. Total egg number counted and recorded daily.

b. Volume of egg ($cm^3$):

Egg volume was calculated based on the length and breadth (mm) following the formula; $V = k_vLB^2$ where, kv = coefficient and the value is 0.496 (Narushin, 1997a).

c. *Shape index:* (Breadth / Length) x 100

d. *Surface area ($cm^2$):*

According Narushin, 2004, the surface area of egg was calculated according to the following equation, $S = k_sLB$; where $k_s$ is the coefficient, (3.155-0.0136L+0.0115B, and L = length, B = Breadth of the egg).

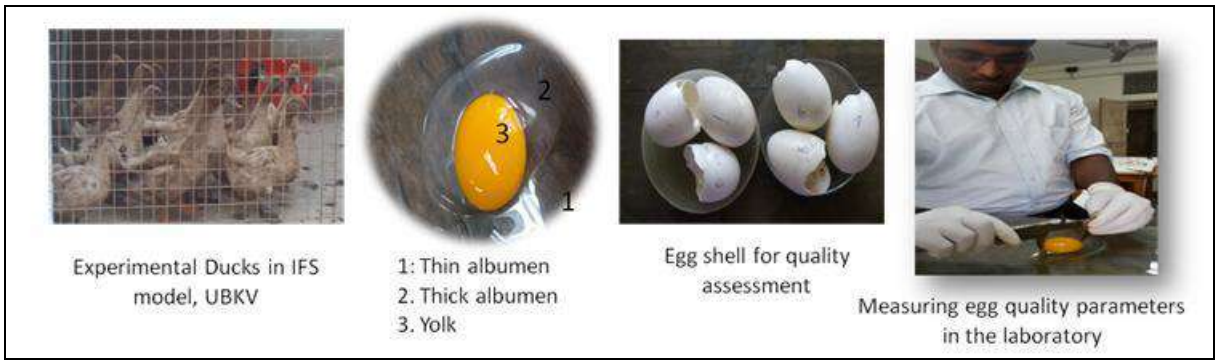



**Figure 1: Instructional and model duck (Khaki Campbell) rearing practice and subsequent assessment of egg quality parameters in the laboratory**

e. Shell weight (gm):

Egg shell devoid of albumen or yolk is dried overnight at hot air oven then weighted by an electronic balance with 0.001 precision.

f. Haugh Unit:

HU was determined according to the following equation: HU = 100 log (H+7.57-1.7 W 0.37); H = height of the thick albumen, W = weight of the egg

g. Yolk index (YI):

YI was calculated based on the average length, width measured by vernier caliper and the yolk height by using a tripod following the underneath equation

Yolk index = (Yolk height / Yolk diameter) x 100

h. Egg shell thickness

Eggshell thickness was measured by a means of micrometer as an average of 3 points (top, medial and base).

✓ ***Determination of fertility and hatchability***

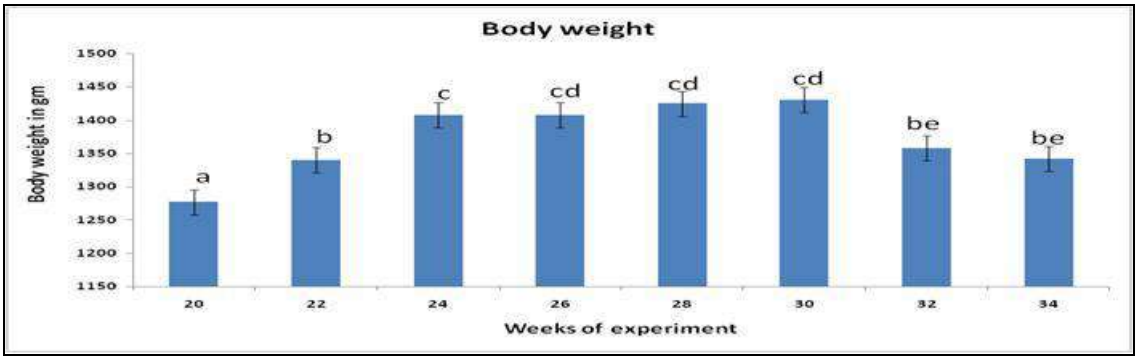
The eggs were collected daily and stored at room temperature for up to 4 days before they were placed in the incubator. Eggs are incubated automatically under standard humidity and temperatures. On the 15-18$^{th}$ day, an accurate assessment of the developmental stage of the embryo by candling was done, numbers of eggs containing dead embryos, those containing no embryo were counted and the percent of fertility was calculated. Hatching process usually started on 25$^{th}$ day finished by the end of 28$^{th}$ day, the chicks were removed and counted. Fertility and hatchability percentages were calculated as the following:

$$\text{Fertility (\%)} = \frac{\text{No of hatched eggs + No of eggs containing embryo}}{\text{Total number of incubated eggs}} \times 100$$

$$\text{Hatchability (\%)} = \frac{\text{No of hatched chicks}}{\text{Number of fertile eggs}} \times 100$$

**Results:**

✓ The reproductive performance of laying birds including Japanese quail deviates upon fluctuation of environmental cues. The present study revealed that laying birds subjected under low ambient temperature showed some changes in their production performance and hatchability indices.




The mean bears different superscript [abc] showed significant difference P<0.05

**Figure 2:** Body weight measurement on fortnight basis in Khaki Campbell duck during low ambient temperature at Terai Zone of West Bengal

**Table 1:** Measurements of external egg quality parameters in Khaki Campbell duck during low ambient temperature at Terai Zone of West Bengal

| **Parameters** | **22w** | **24w** | **26w** | **28w** | **30w** | **32w** | **34w** |
|---|---|---|---|---|---|---|---|
| Egg weight (g) | $54.55^{a}$ | $56.74^{ab}$ | $58.67^{b}$ | $64.40^{c}$ | 65.56c | $61.66^{bc}$ | $65.17^{c}$ |
| Egg Volume ($cm^3$) | $51.69^{a}$ | $56.98^{b}$ | $58.45^{bc}$ | $56.08^{b}$ | $60.14^{c}$ | $62.97^{d}$ | $60.50^{c}$ |
| Egg mass/hen/week | $1527.31^{a}$ | $2383.22^{b}$ | $3285.33^{c}$ | $4057.20^{d}$ | $4589.20^{e}$ | $3021.17^{d}$ | $2737^{cd}$ |
| Shape Index (%) | 69.41 | 63.83 | 70.88 | 69.21 | 75.40 | 74.97 | 68.52 |
| Surface area ($cm^2$) | $70.23^{a}$ | $73.38^{b}$ | $76.10^{c}$ | $77.22^{cd}$ | $79.42^{d}$ | $76.14^{c}$ | $72.27^{ab}$ |
| Shell weight (gm) | 5.53 | 5.17 | 5.89 | 6.34 | 6.01 | 5.69 | 5.54 |

Means bearing un-common superscript in row differ significantly (P<0.05)

**Table 2:** Measurements of internal egg quality parameters in Khaki Campbell duck during low ambient temperature at Terai Zone of West Bengal

| **Parameters** | **22w** | **24w** | **26w** | **28w** | **30w** | **32w** | **34w** |
|---|---|---|---|---|---|---|---|
| Albumen index (%) | 1.51 | 2.31 | 3.27 | 3.92 | 3.24 | 3.44 | 3.14 |
| Albumen ratio | 44.05 | 45.66 | 48.79 | 52.43 | 53.29 | 49.87 | 50.88 |
| Yolk index (%) | 7.36 | 7.83 | 9.57 | 10.45 | 11.16 | 8.63 | 9.21 |
| Yolk ratio | 33.58 | 32.84 | 37.15 | 35.75 | 33.59 | 33.54 | 32.25 |
| Yolk-albumen ratio | 67.11 | 67.32 | 75.90 | 70.96 | 78.67 | 67.82 | 69.01 |
| Haugh unit (%) | 68.96 | 81.99 | 82.92 | 90.34 | 95.94 | 91.66 | 79.83 |

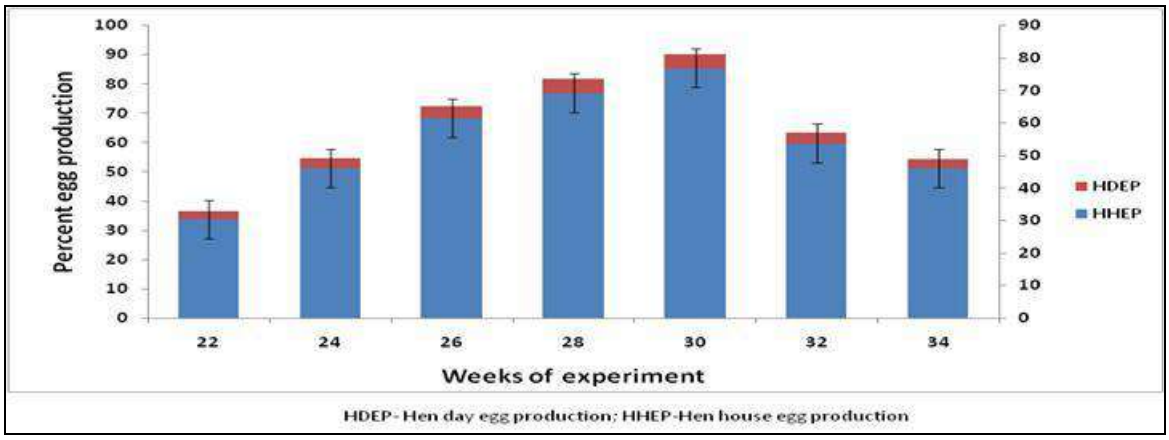



**Figure 3:** Measurement of hen-day and hen-house egg production in Khaki Campbell duck during low ambient temperature at Terai Zone of West Bengal

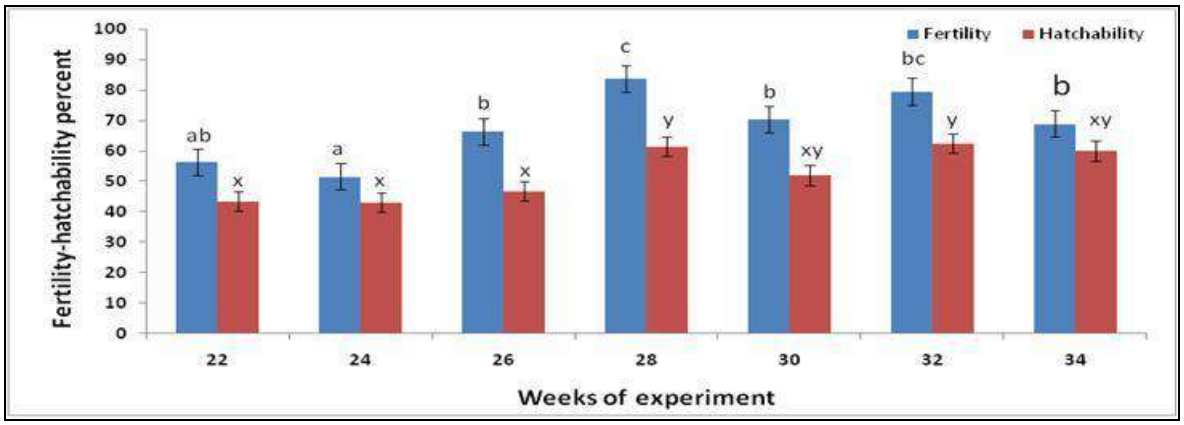


**Figure 4:** Measurement of fertility and hatchability percentage in Khaki Campbell duck during low ambient temperature at Terai Zone of West Bengal

## Findings:

- ✓ Laying birds subjected under low ambient temperature showed an increasing trend of gaining body weight till 30$^{th}$ weeks of age which declined thereafter.
- ✓ The highest peak of shape index and surface area was corresponding with egg weight and recorded on 30$^{th}$ weeks of age.
- ✓ The average weight of egg shell in this study varied between 5.53 to 6.34gm, however, the maximum weight was observed on 28weeks of age.
- ✓ The Haugh unit and Yolk index both revealed highest magnitude on 30$^{th}$ weeks of age when albumen ratio, yolk ratio and yolk-albumen ratio were found on 28$^{th}$ weeks.
- ✓ Maximum fertility (83.91%) and hatchability (61.53) in Khaki Campbell duck were recorded by 28$^{th}$ week of age.

**Future scope:**

- ✓ From this study, it is revealed that nutritional management in terms of ME (Kcal/Kg) and CP (%) value in the duck ration is important along with all other standard management. So, the factors such as optimum plane of nutrition to the birds, control of wind flow and duration of egg storage may be considered for further research trials to standardize as the management tool for better performance.

## Any other information (related to the programme)

- ✓ Because of infrastructural shortfall, the parameters i.e. fertility and hatchability percent were performed in the private organization with due permission of the University authority. These research objectives would be successfully designed in future if the facility could avail in the University corridor.

## ANIMAL SCIENCE AND FISHERIES

**Title of the Programme: Performance trial of different crops with fish under Integrated Farming System Research in the fish farm of RRS, Terai Zone**

**Project code:** RRSTZ/2017-2018/Kharif/06

**Associate Scientist/s:** Prof. Debapriya Sarkar and Dr. Nilanjana Chaudhuri

**Objectives:**

- ✓ To study the performance of Turmeric grown organically fish pond adjoining area
- ✓ To study the performance of Ginger grown in pond dyke and fish pond adjoining area
- ✓ To study the performance of Elephant foot yam in pond dyke
- ✓ To study the performance of plantation crops in pond dyke
- ✓ To study the performance of paddy-cum-fish culture in low lying pond adjoining areas
- ✓ To study the performance of water tolerant paddy variety in low lying pond adjoining areas with organic package of practice
- ✓ To study the performance of muga silkworm host plant (som) in medium land and the effect of nutrient supplementation and intercropping to make them grow fast in terai agro-climatic situation.
- ✓ To study the performance of lentil and maize in low lying pond adjoining areas area in rabi
- ✓ To study the performance of fish in fish farm pond

**Materials:**

*Objective 1*

- ✓ Turmeric variety TCP 2 (Suranjana)
- ✓ Solid and liquid indigenous microbial culture,
- ✓ Handmade botanical insecticide (Agniastra)

*Objective 2*

- ✓ Ginger variety Local
- ✓ NPK at recommended dose and liquid indigenous microbial culture,
- ✓ Handmade botanical insecticide (Agniastra)

*Objective 3*

- ✓ Elephant foot yam variety Kavur
- ✓ NPK at recommended dose

*Objective 4*

- ✓ Areca nut and Coconut
- ✓ NPK at recommended dose

*Objective 5*

- ✓ The total area 225 $m^2$(paddy variety RajendraMashuri in 180 $m^2$ area, water channel 20 $m^2$ area (excluding 1m depth) for fish and dyke 25 m 2area.
- ✓ Solid and liquid indigenous microbial culture,

- ✓ Handmade botanical insecticide (Agniastra)

*Objective 6*

- ✓ Paddy variety RajendraMasuri, Nilanjana, MTU 1075 and Sabita
- ✓ Solid and liquid indigenous microbial culture,
- ✓ Han made botanical insecticide (Agniastra)

*Objective 7*

- ✓ Muga host plant Som (Machilusbombycina) as main crop.
- ✓ Turmeric, vegetable, spices, legume and oil seed crops as intercrops.
- ✓ Solid and liquid indigenous microbial culture.
- ✓ Handmade botanical insecticide (Agniastra)

*Objective 8*

- ✓ Lentil variety Moitree
- ✓ Solid and liquid indigenous microbial culture,
- ✓ Handmade botanical insecticide (Agniastra)
- ✓ NPK

*Objective 9*

- ✓ IMC like Catla, Rohu and Mrigel fries weighing 2cm and 1.5g
- ✓ Feed pellet (4 mm)

**Methodology:**

*Objective 1*

- ✓ Turmericrhizome was planted during 1stweek of May in the 125$m^2$ plot.
- ✓ Solid indigenous microbial culture applied during field preparation.
- ✓ After that liquid indigenous microbial culture, was applied at fortnightly interval.
- ✓ Agniastra was applied as need based.
- ✓ The crop was harvested in February, 2018
- ✓ The observations of plant and yield parameters for conventional farming were taken from the field maintained under University farm.

*Objective 2*

- ✓ In the fish pond adjoining area (100 m2) Gingerrhizome was planted1st week of May, 2017 and in the same plot lentil was sown during 1st week of December, 2017.
- ✓ In the pond dyke only ginger was raised in 150 m2area.
- ✓ NPK at recommended dose applied during field preparation for ginger.
- ✓ After that liquid indigenous microbial culture, was applied at fortnightly interval.
- ✓ Agniastra was applied as need based.
- ✓ All the crop were harvested in March,2018

*Objective 3*

**ANIMAL SCIENCE AND FISHERIES**

- ✓ Tuber of Elephant foot yam was sown during 1stweek of May in the 200 m2 area.
- ✓ Recommended agronomic practices were followed
- ✓ The crop was harvested in January,2018
- ✓ The average weight of each rhizome was 700 gm
- ✓ The yield was 7t/ha.

*Objective 4*

- ✓ 50 number of areca nut and 20 number of coconut seedlings were transplanted on and around the pond dyke during May, 2017.
- ✓ Recommended agronomic practices were followed

*Objective 5*

- ✓ The 21 days old seedling was transplanted during2nd fortnight of July, 2017
- ✓ Solid indigenous microbial culture during land preparation and after that liquid at fortnight interval
- ✓ The botanical insecticide (Agniastra) was applied as per need.
- ✓ Fish were released into the paddy field after 15 days of rice transplantation. Asian magur hatchlings (50 numbers and 20 days old) and freshwater prawn juveniles (100 numbers and 45 days old) were released in first phase. IMC fries name namely Rohu and Mrigel (1 kg and 30 days old) were released in the second phase.
- ✓ Growth of fish was checked monthly by netting.
- ✓ The crop was harvested in November, 2017

*Objective 6*

- ✓ Paddy variety namely RajendraMashuri, MTU 1075, Sabita and Nilanjana were raised in the plot size of 180 sq.m, 70 sq.m., 250 sq.m. and 110 sq.m. respectively
- ✓ 21 days old seedlings were transplanted by 1st fortnight of August
- ✓ Solid indigenous microbial culture applied during field preparation.
- ✓ After that liquid indigenous microbial culture, was applied at fortnightly interval.
- ✓ Agniastra was applied as need based.
- ✓ The crop was harvested in November-December,2017
- ✓ The observations of plant and yield parameters for conventional farming were taken from the field maintained under University farm.

*Objective 7*

- ✓ Muga host plant (100 numbers) was planted in 3mx3m in the medium land during 3rd week of September, 2017.
- ✓ The plants were transplanted in two parts, in one part of 250 m2 area the turmeric germplasm TCP 70 was planted during 1st week of May
- ✓ In the other part of 470 m2 area different vegetable, legume and oil seed crops was sown/transplanted during 2ndweek of December, 2017.
- ✓ Solid indigenous microbial culture applied during field preparation.
- ✓ After that liquid indigenous microbial culture, was applied at fortnightly interval.
- ✓ Agniastra was applied as need based.

- ✓ The turmeric was harvested in February,2018, vegetable, spices, legumes and oilseed crops were harvested in 1st week of April
- ✓ The observations of plant and yield parameters of turmeric for conventional farming were taken from the field maintained under University farm.

*Objective 8*

- ✓ Lentil and maize were sown duringlast week of December, 2017
- ✓ Both the crops were raised organically in 130 m2 plot and by conventional farming in 100 m2 area.
- ✓ Solid indigenous microbial culture applied during field preparation.
- ✓ After that liquid indigenous microbial culture, was applied at fortnightly interval.
- ✓ Agniastra was applied as need based.
- ✓ In conventional farming normal agronomic practices were followed
- ✓ The crop was harvested in March and May,2018

*Objective 9*

- ✓ Recommended package of practice for composite fish culture in rearing pond has been followed for 16 kg of fries
- ✓ The crop was released in the month of June 2017 and harvested up to May, 2018.

**Results:**

*Objective 1*

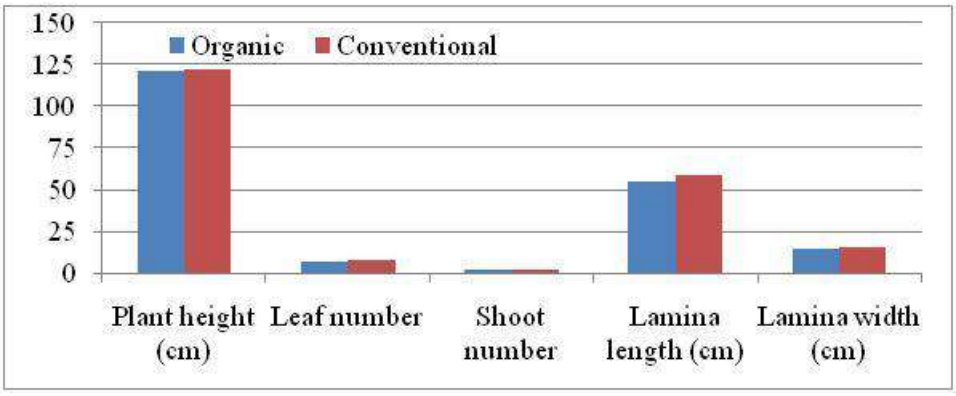



**Figure 1: Plant parameters of turmeric (variety Suranjana) raised in two different farming system**

**ANIMAL SCIENCE AND FISHERIES**

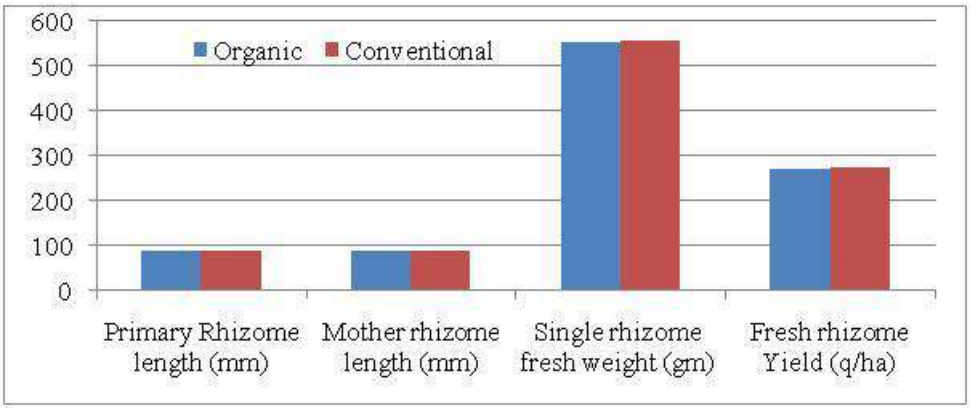



**Figure2: Yield attributing parameters of turmeric (variety Suranjana) raised in two different farming system**

*Objective 2*

**Table 1: Plant and yield attributing parameters of ginger (variety local)**

| Plant height (cm) | Shootnumber | Lamina length (cm) | Lamina width (cm) | Single rhizome fresh weight (gm) |
|---|---|---|---|---|
| 61.23 | 23.25 | 19.45 | 1.98 | 500 |

**Table 2: Comparative account of yield in two types of land situation**

| **Area** | **Crop** | **Yield t/ha** |
|---|---|---|
| Pond dyke | Ginger | 2.235 |
| Medium land adjacent to fish pond | Ginger | 2.558 |
| | Lentil | 1.50 |

*Objective 5*

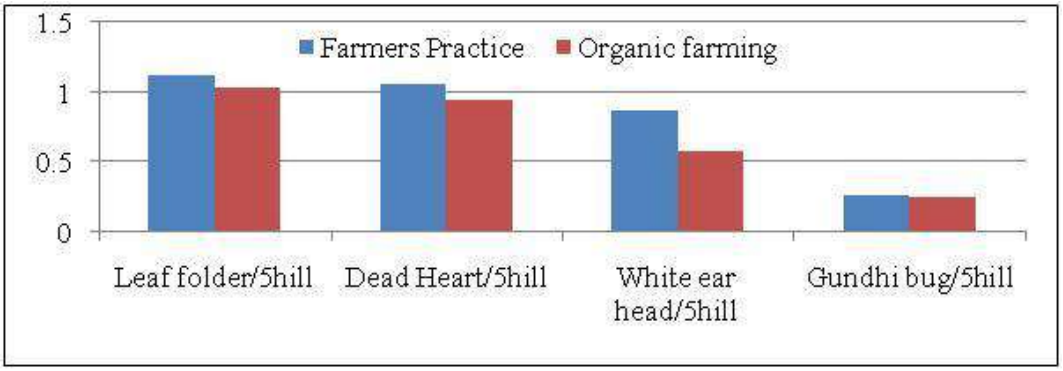



**Figure 3: Pest population infesting paddy in Kharif 2017**

## ANIMAL SCIENCE AND FISHERIES

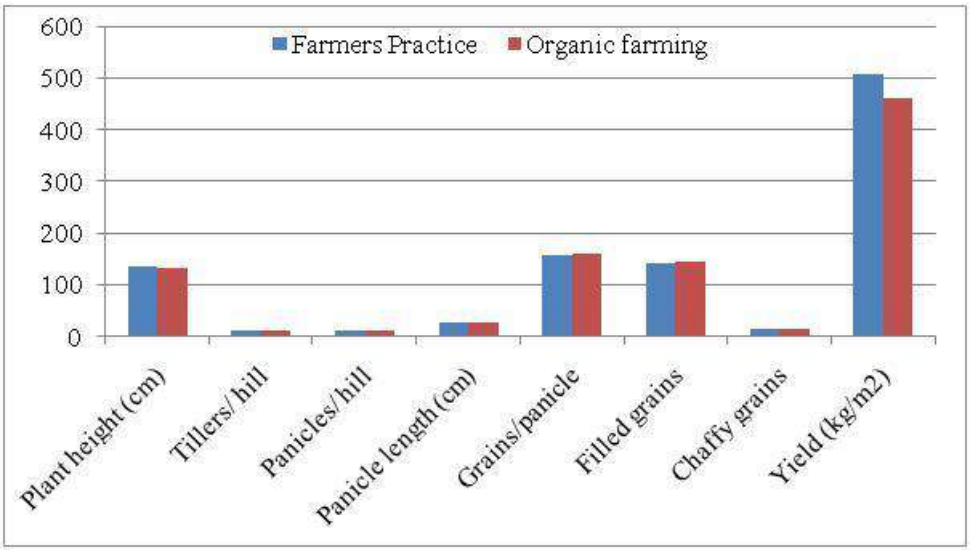



**Figure 4: Influence of cultivation practices on plant parameters of paddy at maturity**

**Table 3: Growth performance of fish in paddy field**

| Parameters * | Fish Species | | | |
|---|---|---|---|---|
| | Rohu | Mrigel | Asian Magur | Prawn |
| Av Initial length (cm) in Aug | 2.5 | 2.2 | 2.0 | 1.5 |
| Av Initial weight (g) in Aug | 1.8 | 1.9 | 1.3 | 0.15 |
| Av length (cm) in Sep | 8.4 | 8.7 | - | 1.8 |
| Av weight(g) in Sep | 8.0 | 8.9 | - | 0.6 |
| Av length (cm) in Oct | 10.2 | 12.2 | - | 2.8 |
| Av weight(g) in Oct | 37 | 49 | - | 4 |
| Av final length (cm) in Nov | 11 | 14 | 14 | 6 |
| Av final weight(g) in Nov | 55 | 65 | 20 | 10 |
| Fish released | 0.5 kg | 0.5 kg | 50 nos | 100 nos |
| Fish production | 2.0 kg | 3.0 kg | 10 nos | 22 nos |
| Control weight (individual)(g) | 35 | 40 | 35 | 30 |

*No of sample taken to calculate average data is 4

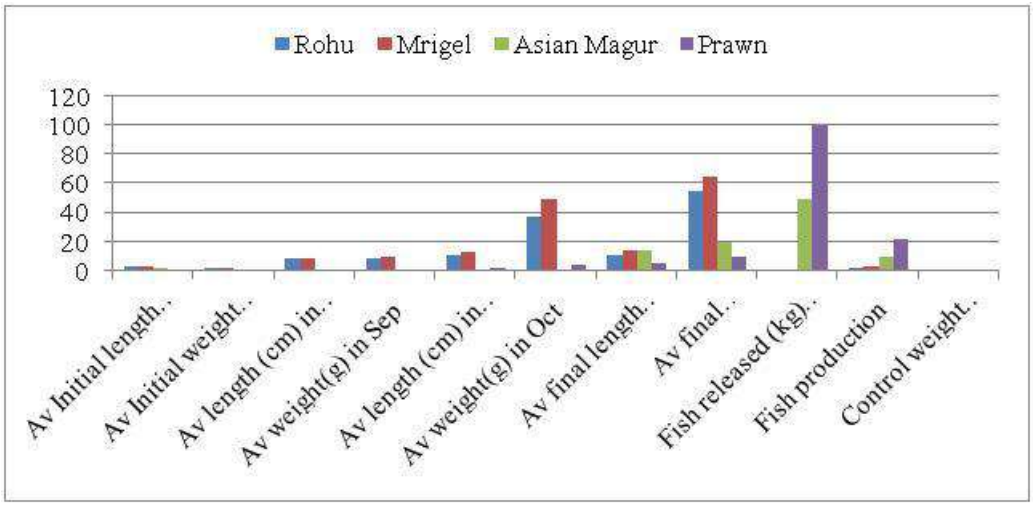



**Figure 5: Growth performance of fish**

## ANIMAL SCIENCE AND FISHERIES

*Objective 6*

**Table 3: Pest population infesting paddy varieties raise organically in Kharif 2017**

| Insect-pest populations | RajendraMashuri | | MTU 1075 | | Nilanjana | | Sabita | |
|---|---|---|---|---|---|---|---|---|
| | FP | OC | FP | OC | FP | OC | FP | **OC** |
| Leaf folder/5hill | 1.12 | 1.03 | 1.02 | 1.01 | 1.56 | 1.00 | 1.38 | 1.02 |
| Dead Heart/5hill | 1.06 | 0.95 | 1.00 | 0.85 | 1.23 | 1.11 | 1.14 | 1.02 |
| White ear head/5hill | 0.87 | 0.58 | 0.21 | 0.11 | 1.02 | 0.97 | 1.05 | 1.02 |
| Gundhibug/5hill | 0.27 | 0.25 | 0.21 | 0.14 | 0.32 | 0.21 | 0.37 | 0.30 |

FP= Farmers Practice; OC= Organic Cultivation

**Table 4: Influence of cultivation practices on plant parameters of paddy varieties at maturity**

| **Plant Parameters** | **RajendraMashuri** | | **MTU 1075** | | **Nilanjana** | | **Sabita** | |
|---|---|---|---|---|---|---|---|---|
| | **FP** | **OC** | **FP** | **OC** | **FP** | **OC** | **FP** | **OC** |
| Plant height (cm) | 135.65 | 133.20 | 125.88 | 123.75 | 145.69 | 142.65 | 173.74 | 171.69 |
| Tillers/hill | 13.12 | 11.32 | 14.10 | 13.05 | 13.24 | 12.15 | 14.33 | 12.85 |
| Panicles/hill | 12.89 | 11.04 | 13.85 | 12.50 | 13.00 | 12.02 | 14.00 | 12.35 |
| Panicle length (cm) | 27.45 | 28.04 | 23.77 | 24.05 | 21.21 | 22.00 | 23.57 | 24.18 |
| Grains/panicle | 158.65 | 159.33 | 273.67 | 277.69 | 158.26 | 161.00 | 157.24 | 163.02 |
| Filled grains | 141.80 | 144.81 | 240.67 | 249.02 | 138.25 | 144.33 | 137.12 | 141.67 |
| Chaffy grains | 16.85 | 14.52 | 33.00 | 28.67 | 20.01 | 16.67 | 20.12 | 21.35 |
| Yield (kg $m^{-2}$) | 507.2 | 459.7 | 502.5 | 282.3 | 463.4 | 457.5 | 412.6 | 410.2 |

*Objective 7*

**Table 5: Plant parameters of turmeric (germplasm TCP 70) raised in som plantation**

| Farming practice | Plant height (cm) | Leaf number | Shoot number | Lamina length (cm) | Lamina width (cm) |
|---|---|---|---|---|---|
| Organic | 119.23 | 8.4 | 2.8 | 57.5 | 14.95 |
| Conventional | 124.32 | 9.2 | 3.2 | 61.8 | 16.25 |

**Table 6: Yield and yield attributing parameters of turmeric (germplasm TCP 70) raised in som plantation**

| Farming practice | Primary Rhizome Length (cm) | Mother rhizome length (cm) | Single rhizome fresh weight (gm) | Fresh rhizome Yield (t/ha) |
|---|---|---|---|---|
| Organic | 7.56 | 7.78 | 385.23 | 19.86 |
| Conventional | 8.00 | 7.89 | 388.25 | 20.56 |

**ANIMAL SCIENCE AND FISHERIES**

**Table 7: Yield Performance of different crops in som plantation**

| Crop | Yield (t/ha) |
|---|---|
| Cabbage | 11.82 |
| Tomato | 30.15 |
| Carrot | 12.35 |
| Chilli | 16.56 |
| Pea | 9.32 |
| Lentil | 1.54 |
| Garlic | 1.85 |

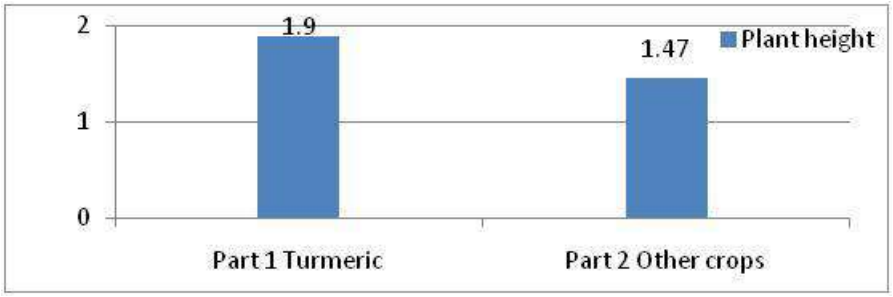



**Figure 6 : Performance of som plants**

*Objective 8*

**Table 8: Performance of Lentil variety Moitree WBL77in two different farming system**

| Farming practice | Aphids /leaf | Yield gm plant$^{-1}$ | Yield t ha$^{-1}$ |
|---|---|---|---|
| Organic | 0.47 | 82.29 | 1.626 |
| Conventional | 0.68 | 78.83 | 1.616 |

**Table 8: Performance of Maize variety: DKC9081in two different farming system**

| Farming practice | Aphids Leaf $^{-1}$ | Leaf roller (folded leaves) Plant$^{-1}$ | Single Cob weight (gm) | Yield t ha$^{-1}$(fresh weight) |
|---|---|---|---|---|
| Organic | 0.50 | 0.047 | 248.35 | 4.09 |
| Conventional | 0.98 | 0.090 | 483.40 | 14.01 |

*Objective 9*

- ✓ Recommended package of practice for composite fish culture in rearing pond has been followed for 16 kg of fries
- ✓ The crop was released in the month of June 2017 and harvested up to May,2018

**ANIMAL SCIENCE AND FISHERIES**

**Findings:**

*Objective 1*

- ✓ Plant and yield attributing parameters of Suranjanawere higher in conventional farming than the organic one but the difference was non-significant.
- ✓ Yield of TCP 70 was less than Suranjana. It was fade in colour and fresh weight of single rhizome was also lesser (388 g).

*Objective 2*

- ✓ Plant growth as well as rhizome growth is moderate.
- ✓ Ginger intercropped with lentil provided higher return as compared to sole crop.

*Objective 3*

- ✓ The average weight of each rhizome was 700 gm
- ✓ The yield was 7t/ha.

*Objective 4*

- ✓ Crops are growing satisfactorily in the loam soil whereas those in the sandy soil are a bit slow in their growth.

*Objective 5*

- ✓ The insect pest populations (leaf folder, yellow stem borer and gundhi bug) were observed more in the farmers practice than organically managed experimental plot.
- ✓ Plant height was comparatively higher in farmers' practice.
- ✓ Number of tillers/hill, panicles/hill, panicle length and grains/panicle were relatively more in organic farming over conventional farming.
- ✓ The yield was slightly lower in organic farming than conventional one.
- ✓ Growth of rohu and mrigel in the paddy field as well as water channel is optimum. However it is expected to enhance several manifolds with the increase in area under paddy-cum-fish cultivation and increase in water area and depth holding the fish throughout the culture period.
- ✓ Though the growth record of asianmagur is satisfactory but number harvested is really frustrating which is because of their escaping nature and its needs further protection across the dyke area of the land using strong and high nets so as to control escaping of fish.
- ✓ Performance of freshwater prawn juvenile in paddy field is not so satisfactory as in pond they grow much bigger where a separate care for their feeding is adopted. In the paddy field cannibalistic behaviour of prawn resulted in reduction in their number. At the same time, lack of sufficient food could not result in the optimum yield.

*Objective 6*

- ✓ The important insect-pests infesting paddy were stem borer, leaf folder and gundhi bug. The population was maximum in the field in conventional than organic farming.
- ✓ Plant and yield attributing parameters were comparatively higher in farmers' practice than organic cultivation.
- ✓ Yield performance followed an order of RajendraMashuri>Nilanjana>Sabita>MTU 1075

*Objective 7*

- ✓ The som plantintercropped with turmeric as well as different vegetables, legumes and oil seed crop attained the height of 1.90ft and 1.47ft respectively at 7 months after transplanting.
- ✓ Plant and yield attributing parameters of turmeric were slightly higher in conventional farming than the organic one but the difference was non-significant.

*Objective 8*

- ✓ Pest population of lentil and maize was observed lower in organically managed plots.
- ✓ The yield attributing parameters of lentil were higher in organic farming than the conventional one.
- ✓ The yield attributing parameters of maize were higher in conventionalfarming than the organic one.

*Objective 9*

- ✓ Average weight and length of fish were 80g and 25 cm respectively.
- ✓ Approximately 10 % of fish population are growing upto 300g.

**Future Scope:**

*Objective 1*

- ✓ There lies a huge scope to explore optimum growth and yield of this crop through continuous organic soil management applications

*Objective 2*

- ✓ There lies a huge scope to explore optimum growth and yield of this crop through organic soil management applications

*Objective 3*

- ✓ The average weight of each rhizome was 700 gm
- ✓ The yield was 7t/ha.

*Objective 4*

- ✓ There is ample scope of production as well income from this crop cultivated in pond dyke with improvement of soil quality in coming 2-3 years through optimum organic management practice.

*Objective 5*

- ✓ This technology can be adopted in thelow lying areas of teraizone having sandy loam soil and also in some other localities having less frequent ponds to obtain high paddy as well as fish yield from the paddy-cum-fish culture plots.

*Objective 6*

- ✓ Identification of more number of water tolerant variety of paddy for execution of paddy-cum-fish culture with organic culture practice in the low lying areas for better profit and sustainability.

*Objective 7*

- ✓ Improved growth will lead the plants to reach an optimum height required for muga silkworm rearing within shortest possible time and the lean period can be exploited by the farmer through income from the intercropped vegetables and spices.

*Objective 9*

- ✓ Larger fish can be used after one year for induced breeding to produce quality for future use

**Recommendation**

*Objective 1*

- ✓ The yield of turmeric is almost same in both the farming system which suggests bright prospects of adoption of organic farming system for turmeric cultivation in this region.
- ✓ Turmeric has been proved to be one of the most optimally growing horticultural crops in the fish pond adjoining areas of terai zone bearing sandy soil with the help of minimum input and labour cost.

*Objective 2*

- ✓ The potential scope of ginger recommends its incorporation in the IFS system as a valuable spice crop.
- ✓ The quality improvement of sandy soilof pond dyke is essential to make the farming system more remunerative.

*Objective 3*

**ANIMAL SCIENCE AND FISHERIES**

- ✓ The yield is not satisfactory this year as the crop was grown in the dyke containing highly sandy soil and it needs more attention for soil texture improvement in terms of nutrient supplement to the crop bearing plots.

*Objective 4*

- ✓ Proper growth of the plants in coming 5-6 years will make the IFS unit economically strong.

*Objective 5*

- ✓ Recommendation can be done after continuous conduction of the same experiment for 2 years in at least 1 acre plot.

*Objective 6*

- ✓ The result suggests bright prospects of adoption of sustainable organic farming system for paddy–cum –fish cultivation in terai region. Components of solid indigenous microbial culture and agniastra are mostly domestic and easily available and cheaper in price that will augment the technology adoption by the stakeholders.

*Objective 7*

- ✓ The gestation period of muga host plant is 4-5 years and to minimize the period, the option of intercropping in the inter spaces of som plants can be a better option.

# ANIMAL SCIENCE AND FISHERIES

# ANIMAL SCIENCE AND FISHERIES

## CROP IMPROVEMENT

**Title of the Programme:** ***Performance of grafted tomato (Stock: UBB-8Scion: Meghali) for enhancing the resistance against biotic stress***

**Project code:** RRSTZ/Rabi/17-18/08

**Associate Scientist/s:** Dr. Hossain Ali Mondal

**Objectives:**

- ✓ Low cost (Stock: UBB-8Scion: Meghali) grafted tomato seedling production technology
- ✓ Grafted tomato for enhancing the resistance against biotic stress
- ✓ Assuring farmer's enhanced income
- ✓ Use of lesser chemical dependent farming practice.

**Materials (in details):**

- ✓ Soil-rite, Seedling of both Tomato and Brinjal, grafting clip, Transparent plastic container, Plant Growth Room conditioned with the soil-rite as soilless growing media under 3000 lux of light intensity, 14-hour light condition per day, and 70% of Relative Humidity.

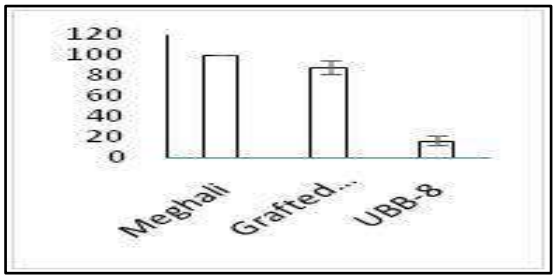
**Methodology**:

- ✓ First allow the growth of root stock [here Brinjal for 14 days (UBB-8, Signath)].
- ✓ Initiation of SCION (here Tomato variety, ArkaMeghali, a high yielding genotype developed by IIHR) germination after 14 days later. Here it is abbreviated as Stock: UBB-8.
- ✓ Cut the stock and scion with the surgical blade.
- ✓ Stabilize the stock and scion with the help of grafting clip.
- ✓ Keep for 14 days in humid condition in the transparent plastic box in the PGR (Plant Growth Room)conditioned with the soil-rite as soilless growing media under 3000 LUX of light intensity, 14-hour light condition per day, and 70% of Relative Humidity.
- ✓ 30 days from grating date, the plant was considered for main field.

**Results**:

- ✓ The resistant Brinjal, UBB-8 (Signath) showed the wilt resistant.
- ✓ All tomato plant, Meghali showed wilt susceptible.
- ✓ All the grafted tomato (Stock: UBB-8Scion: Meghali) also showed wilt susceptible.

**Table 1:** Percentage of Wilt infection in Non-grafted Meghali, Grafted Meghali and Brinjal used as root stock.



**CROP IMPROVEMENT**

[Percentage of infection to wilt disease of UBB-8, Meghali and Grafted Meghali at 2 months in the field condition. All the un-grafted Meghali were faced to wilt susceptibility whereas the grafted tomato 88.25% infection to wilt disease. UBB-8 showed lower susceptibility rate (16.67%) as compared to both, Grafted Meghali and Un-grafted Meghali.]

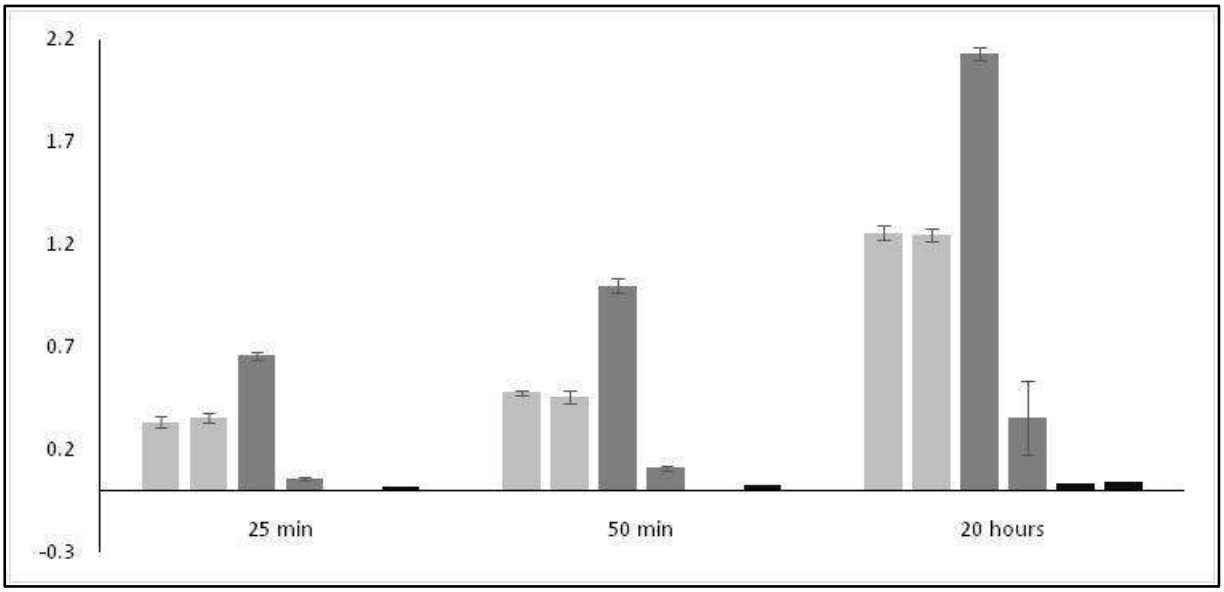



**Figure 1: Bacterial count in UBB-8, Grafted tomato and ungrafted tomato**

[In each series, there are 6 bars. First two bars (1&2) are assigned as Ungrafted-Meghali Upper and Lower, marked as light shaded. Next two bars (3 and 4) are assigned as Grafted-Meghali Upper and Lower, marked as more dark shade. Next two bars (5&6) are assigned as UBB-8 Upper and Lower, marked as darkest shaded.

Bars No. 1&2: All the un-grafted Meghali were infected to wilt disease realized in two months. The both upper and lower parts which are recognised as Above Ground and Below ground Plant parts showed the infestation of bacterial population. In temporal scale of ooze-out data reflects the linear fashion of release of infected bacteria.

Bras No. 3&4: 88.25% grafted-Meghali were infected to wilt disease realized in two months. The both upper and lower parts which are recognised as Above Ground and Below ground Plant parts showed the infestation of bacterial population. Very interesting, the below ground plant parts, marked as below the grafting region and part of stock, UBB-8 is highly less populated significantly as compared to Above ground plant parts, belong to Meghali as Scion. In temporal scale of ooze-out data reflects the linear fashion of release of infected bacteria from both parts. The Above ground Scion part is highly populated as compared to un-grafted Meghali. How these bacteria are harboured under this region is assigned as big question.

Bars 5&6: The UBB-8 is also faced bacterial wilt up to 16.67% in the wilt sick plot. Very interesting, the upper and lower plant parts showed much significantly lower bacterial population as compared to all plant parts either lower or upper from un-grafted and grafted Meghali.]

## CROP IMPROVEMENT

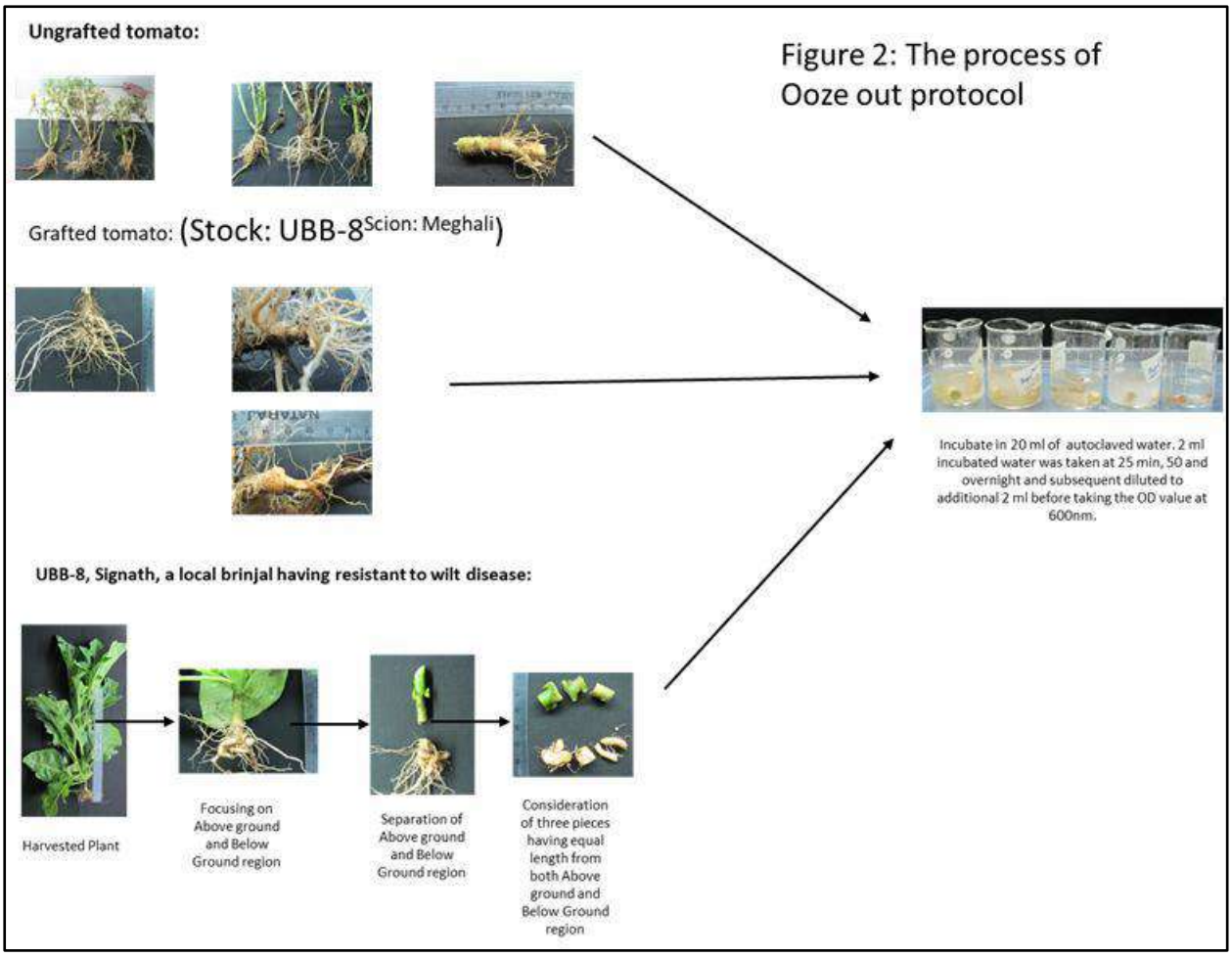



**Figure 2: The process of Ooze out protocol**

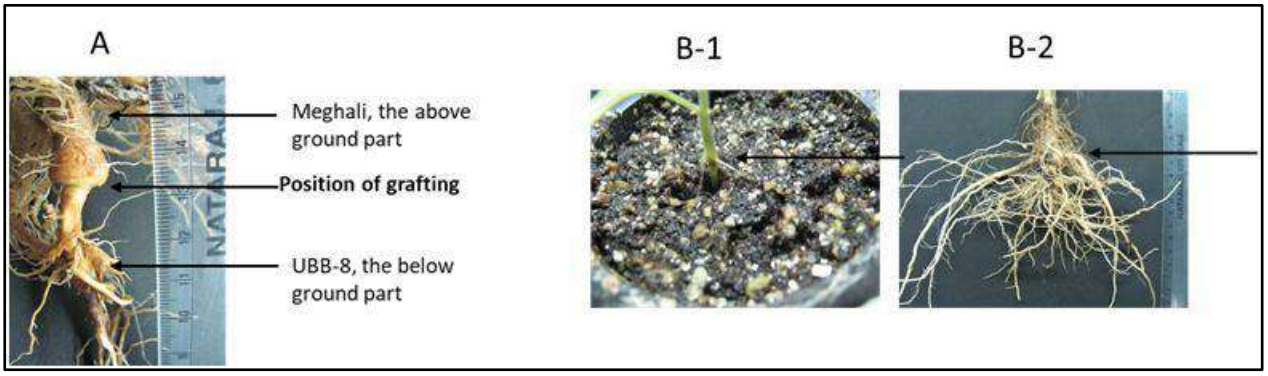
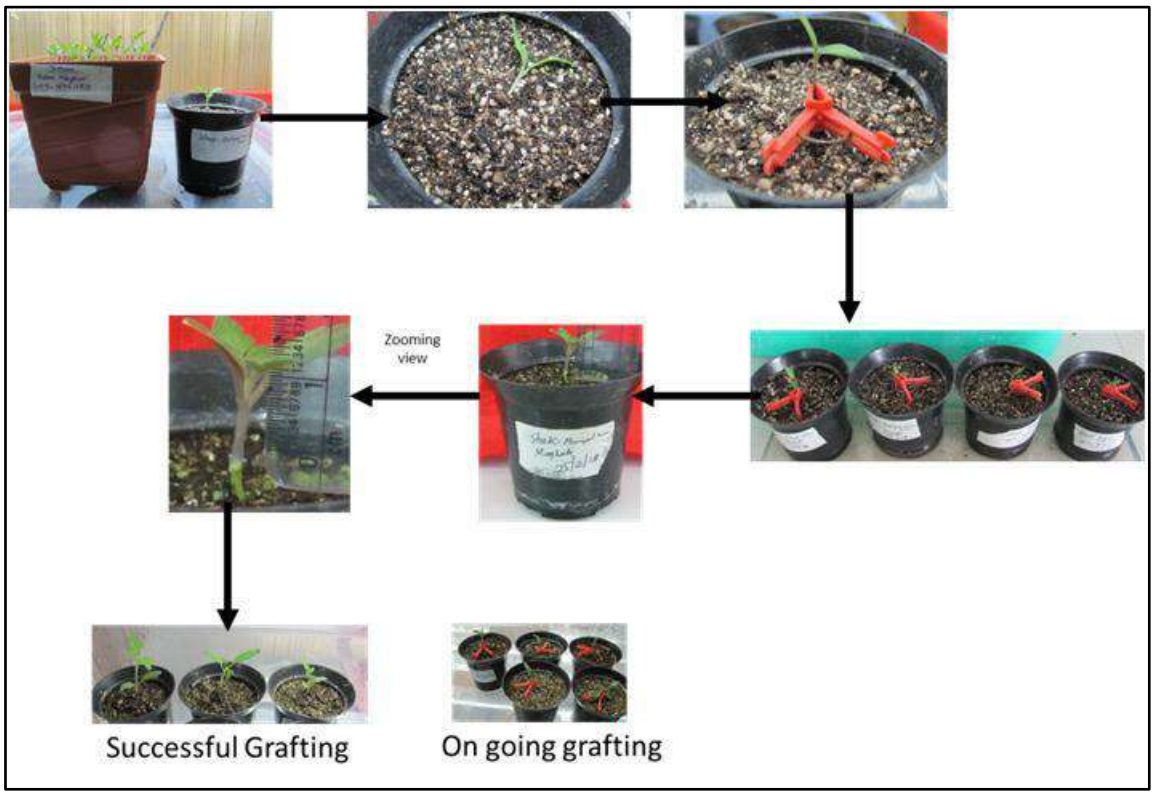



**Figure 3: The potent reason of high bacterial population in the above ground plant parts in grafted Meghali.**

[Figure 3.A: In the mature plant, the grafting place was arrowed. The above position of grafting place was reflected as enhanced bacterial population estimation but in the below the grafting place which is the part of UBB-8, a bacterial wilt resistant brinjal plant was reflected as reduced bacterial population. The high population in the above ground position was not due to below ground parts due to very low population of bacteria. The presence of very lower population in the UBB-8 below ground nullify the bacterial infiltration from stock root in the grafted Meghali. It may be leached from above ground position. The main issue is the enhanced bacterial population in the above ground portion in the

grafted tomato. The one potent reason may be due to presence of root development from the above ground plant parts which belongs to Meghali plant part. The tendency of development of root from Meghali stem is also realized in the development of grafted Meghali in Plant Growth Room which is shown in Figure 3.B-1 and later on reflected on mature plant shown in Figure B-2]




**Supplementary Figure 1: An initiative of grafting of High Yielding Tomato Variety (ArkaMeghali) on local Brinjal root stock**

**Findings:**

- ✓ The high yielding variety, Meghali showed 100% susceptibility to filed condition.
- ✓ The grafted tomato (Stock: UBB-8Scion: Meghali) plant rescued the susceptibility in the field condition.
- ✓ The stock, UBB-8 used in grafted Meghali showed resistance to wilt disease in the field condition.
- ✓ The root development from scion may actually contribute the susceptibility of the grafted tomato.

**Future Scope:**

- ✓ Need continuation of this project mainly focusing on root development from scion in grafted tomato.

## CROP IMPROVEMENT

**Recommendation :**

- ✓ Alternative idea needs to be conceptualized for inhibiting the rooting growth from Above Ground Scion in grafted tomato plant.

**Any other information (related to the programme)**:

- ✓ Rootless Graft development was initiated for avoiding the rescue of susceptibility.

## CROP IMPROVEMENT

**Project Title**: Selection of mungbean genotypes for tolerance to water-logging under field condition

**Project code:** RRSTZ/Rabi/17-18/05

**Associate Scientist/s:** Dr. Rupsanatan Mandal

**Objectives:**

- ✓ Identification of flood tolerance genotypes suitable for Terai Zone, West Bengal

**Materials:**

- ✓ . Ten mungbean genotypes viz. Samrat, Sonali, Sukumar, Panna, Birerswar, Selection -1, Selection-2, TC-39487, TC-39499, and TC-39544 were tested under this study.

**Methodology**:

- ✓ The experiment was conducted in the field of the Regional Research Station, Terai Zone, Uttar Banga Krishi Viswavidyalaya, Pundibari, Coochbehar during November, 2017 to February, 2018.
- ✓ The genotypes were flooded with 3-5 cm of standing water for 7 days (96 hours) at 25 days after emergence (DAE), 35 days after emergence and 45 days after emergence.
- ✓ The experiment was laid out in a split-plot design with three replications.
- ✓ Flooding treatments were placed in the main-plots and mungbean genotypes were in the subplots.
- ✓ The size of each main plot was 8m x 2m =16 m2 and the size of each subplot was (2m x 1.5m).
- ✓ Drain in between two main plots was 1.5 m so that flooded water cannot soak to the neighboring experimental plots.
- ✓ Each sub-plot had 5 rows of mungbean genotype with a spacing of 30 cm x 10 cm.
- ✓ At the border of each plot respective mungbean genotype was grown to avoid border effect.

**Results**:

**Table 1: List of mungbean genotypes and percentage of plant survived at 25, 35 and 45 days after emergence of seedlings**

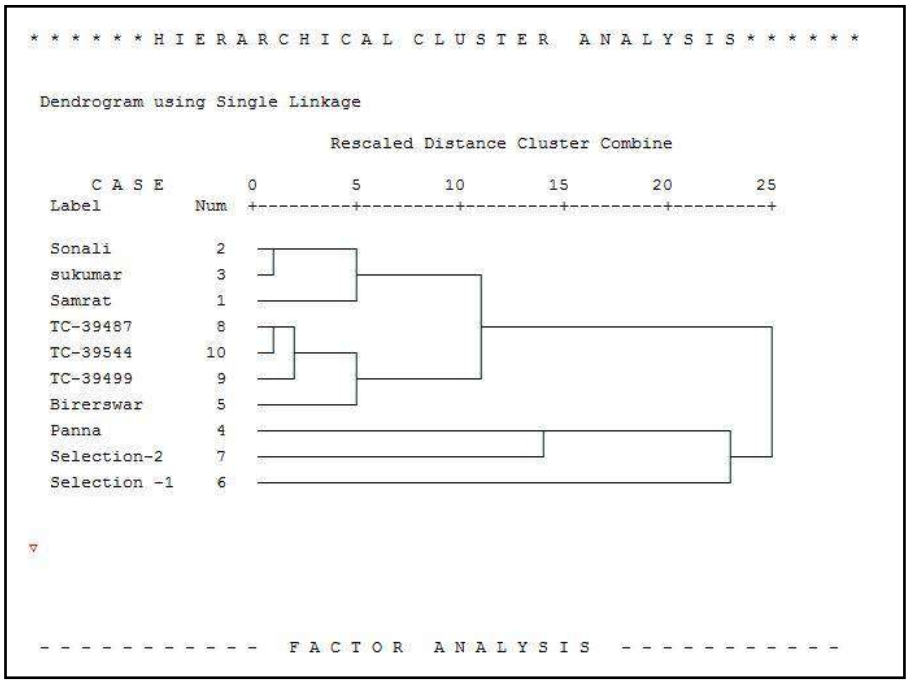
| Genotypes | 25%DAE | 35% DAE | 45% DAE | Grain Yield per Plot |
|---|---|---|---|---|
| **Samrat** | 50.12 | 39.45 | 15.67 | 26.25 |
| **Sonali** | 42.1 | 40.162 | 18.56 | 17.50333 |
| **Sukumar** | 42.75 | 40.56 | 14.87 | 20.83 |
| **Panna** | 5 | 35.96 | 20.45 | 30.92333 |
| **Birerswar** | 45.45 | 35.78 | 23.87 | 20.37667 |
| **Selection -1** | 80.47 | 70.12 | 65.78 | 46.535 |
| **Selection-2** | 85.45 | 72.56 | 67.89 | 27.295 |
| **TC-39487** | 61.78 | 45.32 | 10.56 | 20.555 |

| | | | | |
|---|---|---|---|---|
| **TC-39499** | 59.1 | 38.12 | 13.78 | 20.93833 |
| **TC-39544** | 62.45 | 40.23 | 16.78 | 20.03833 |

**Table 2: Rescaling value of survival % with grain yield of mungbean genotypes**

| Genotypes | 25%DAE | 35% DAE | 45% DAE | GYPP | score | Rank |
|---|---|---|---|---|---|---|
| **Samrat** | 0.561 | 0.100 | 0.089 | 0.301 | 1.051 | 4 |
| **Sonali** | 0.461 | 0.119 | 0.140 | 0.000 | 0.720 | 9 |
| **Sukumar** | 0.469 | 0.130 | 0.075 | 0.115 | 0.789 | 8 |
| **Panna** | 0.000 | 0.005 | 0.173 | 0.462 | 0.640 | 10 |
| **Birerswar** | 0.503 | 0.000 | 0.232 | 0.099 | 0.834 | 7 |
| **Selection -1** | 0.938 | 0.934 | 0.963 | 1.000 | 3.835 | 1 |
| **Selection-2** | 1.000 | 1.000 | 1.000 | 0.337 | 3.337 | 2 |
| **TC-39487** | 0.706 | 0.259 | 0.000 | 0.105 | 1.070 | 3 |
| **TC-39499** | 0.672 | 0.064 | 0.056 | 0.118 | 0.911 | 6 |
| **TC-39544** | 0.714 | 0.121 | 0.108 | 0.087 | 1.031 | 5 |

**Figure 1: Diversity analysis with 11 quantitative characters of mungbean genotypes**




**Major Findings:**

- The genotype Selection-1 and Selection -2 were showed the maximum value of survival in flooding situation with better yield performance.

- According to Dendrogram analysis Selection-1 and Selection-2 also found in same cluster

**CROP IMPROVEMENT**

**Future scope:** This experiment will be done repeatedly for the checking stability of genotypes toward flood tolerance.

**Recommendation:**

- ✓ Samrat cultivars may be cultivated at low land area. It has medium level of water loggind tollerence.
- ✓ The cultivar, Panna is not suitable for cultivation in terai zone.

# CROP PRODUCTION

**Title of the Programme:** ***Effect of seed priming on the performances of wheat cultivars under zero tillage***

**Project code:** RRSTZ/Rabi/17-18/01

**Associate Scientist/s:** Dr. P. S. Patra

**Objectives:**

- ✓ To study the effect of seed priming on the performances of wheat cultivars under zero tillage

**Materials:**

- ✓ Five wheat varieties (C-306, PBW-343, HD-2967, K-1006 and DBW 39)
- ✓ 0.1% solution of $HgCl_2$
- ✓ 50 ppm $GA_3$ Solution

**Methodology:**

- ✓ The present experiment has been conducted at the research farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal during rabi season of 2017 to find out the effect seed priming on the performances of wheat cultivars under zero tillage.
- ✓ The farm is situated at $26^0$19'86" N latitude and $89^0$23'53" E longitude at an elevation of 43 meters above mean sea level.
- ✓ The soil is sandy loam, acidic with a pH of 5.60, low in available nitrogen (151.25 kg $ha^{-1}$), medium in available phosphorus (24.33 kg $ha^{-1}$) and available potash (87.50 kg $ha^{-1}$).
- ✓ The experiment is conducted in factorial randomized block design with three levels of seed priming (hydro-priming, $GA_3$ priming and control) and five varieties.
- ✓ All treatments were replicated three times.
- ✓ Wheat was sown on 19.12.2017 and harvested on 07.04.2018.
- ✓ At first, the wheat seed is disinfected with 0.1% solution of $HgCl_2$ for 5 minutes.
- ✓ Thereafter, seeds were pre-soaked for a period of 24 hours at 25 ± 1 °C either with hydro-priming (pre-soaking with distilled water) or with phyto-hormonal treatment (pre-soaking with $GA_3$ solution made of 50 ppm).
- ✓ Pre-soaked wheat seed is sown by using zero tillage seed cum fertilizer drill.
- ✓ Data were recorded on agronomic parameters including germination%, plant height, no. of spike/sq.m, no. of grains/ spike, test weight and grain yield.

**Results:**

*Germination %*

- ✓ It was observed that irrespective of varieties highest seed germination was found in $GA_3$ primed seed which was followed by hydro-primed seed.

## CROP PRODUCTION

- ✓ Among the varieties PBW-343 recorded highest germination (92%) under $GA_3$ primed treatments followed by C-306 and HD-2967. Normally sown wheat varieties (control) showed lowest seed germination.

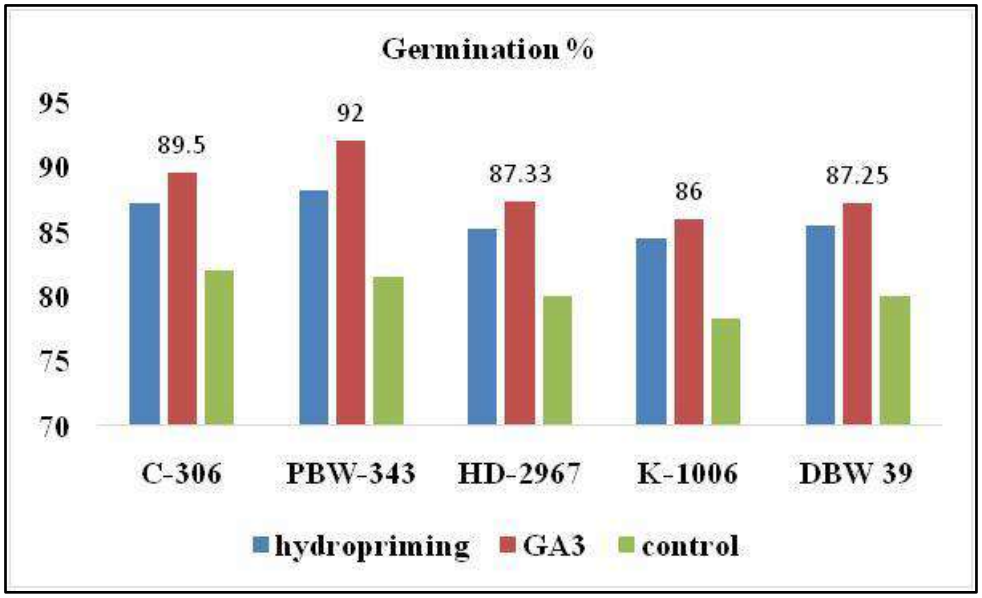



**Figure 1: Effect of seed priming on germination % of wheat varieties**

*Yield attributes and grain yield*

- ✓ Yield attributes and grain yield of wheat are presented in Table 1 and 2.
- ✓ From the tables it is clear that, $GA_3$ primed seed recorded highest values of plant height, no. of spike/sq.m, spike length, no. of grains/spike, test weight and grain yield/ha irrespective of varieties used in the experiment.
- ✓ Among the varieties PBW-343 recorded highest values of plant height (112.02), number of spike/sq.m (376.48), spike length (9.29cm), no. of grain/spike (38.69), test weight (41.52g) and grain yield (3.32 t/ha) followed by C-306, HD-2967, DBW-39 and K-1006 when seed is treated with $GA_3$, probable reason might be due to highest germination percentage and greater root growth.

**Table 1: Effect of seed priming on yield attributes of wheat under zero tillage**

| Treatments | Plant height (cm) | | | No. of spike/sq. m | | | Spike length (cm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Hydro priming | $GA_3$ priming | Control | Hydro priming | $GA_3$ priming | Control | Hydro priming | $GA_3$ priming | Control |
| C-306 | 108.85 | 112.02 | 106.18 | 343.15 | 350.35 | 319.82 | 9.03 | 9.03 | 8.87 |
| PBW-343 | 105.18 | 107.76 | 104.36 | 372.22 | 376.48 | 315.33 | 9.25 | 9.29 | 9.07 |
| HD-2967 | 106.56 | 109.58 | 103.78 | 330.29 | 338.67 | 313.20 | 8.89 | 8.94 | 8.62 |
| K-1006 | 108.14 | 111.35 | 107.42 | 345.56 | 362.45 | 329.10 | 8.85 | 8.87 | 8.68 |
| DBW 39 | 106.33 | 108.96 | 99.95 | 337.17 | 357.82 | 324.25 | 8.96 | 8.99 | 8.8 |

## CROP PRODUCTION

**Table 2: Effect of seed priming on yield attributes of wheat under zero tillage**

| Treatments | No. of grain/spike | | | Test weight (g) | | | Grain yield (t/ha) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Hydro priming | $GA_3$ priming | Control | Hydro priming | $GA_3$ priming | Control | Hydro priming | $GA_3$ priming | Control |
| C-306 | 34.07 | 34.85 | 31.95 | 40.71 | 40.82 | 38.67 | 2.98 | 3.12 | 2.80 |
| PBW-343 | 38.17 | 38.69 | 32.07 | 41.4 | 41.52 | 40.33 | 3.10 | 3.32 | 2.89 |
| HD-2967 | 32.98 | 33.65 | 29.05 | 40.41 | 40.55 | 39.83 | 2.73 | 3.01 | 2.69 |
| K-1006 | 33.15 | 35.5 | 30.12 | 38.5 | 39.15 | 38.01 | 2.87 | 2.95 | 2.70 |
| DBW 39 | 33.65 | 35.98 | 29.33 | 39.04 | 39.15 | 38.74 | 2.82 | 2.97 | 2.75 |

**Plate 1: Effect of seed priming on the yield attributes of wheat**

**Findings:**

- ✓ It is primarily concluded from the one-year data that under zero tillage moisture stress condition seed priming would be a good option for achieving higher seed germination and grain yield.
- ✓ Among the seed priming method hydro-priming would be an easy and cheapest method.

# CROP PRODUCTION

**Title of the Programme:** ***Effect of different dates of planting (DOP) on a heavy panicle rice variety 'Maudamani' in Terai zone of West Bengal***

**Project Code:** Code: RRSTZ/Rabi/17-18/12

**Associate Scientist:** Dr. Parthendu Poddar

**Objectives**:

- ✓ To find out the effect of sowing dates on growth and yield parameters of "CR dhan 307" Maudamani, a heavy panicle rice variety in *Terai* zone of West Bengal
- ✓ To optimise the date of sowing of "CR dhan 307" Maudamani, a heavy panicle rice variety in *Terai* zone of West Bengal

**Materials:**

- ✓ One rice variety (Maudamani)
- ✓ Fertilizers like Urea, SSP and MOP were used as sources of nitrogen, phosphorus and potassium respectively

**Methodology:**

- ✓ The Place of experiment was Uttar Banga Krishi Viswavidyalaya instructional farm, Pundibari, Cooch Behar, West Bengal.
- ✓ The design of experiment was RBD with four replications and treatments were
  **$T_1$** – Transplanting on 02.01.18
  **$T_2$** -- Transplanting on11.01.18
  **$T_3$** -- Transplanting on 20.01.18
  **$T_4$** -- Transplanting on 02.02.18
  **$T_5$** -- Transplanting on17.02.18
- ✓ The plot size and spacing of the experiment were 4m x 4m and 20 cm X 15 cm respectively
- ✓ Method of sowing was mainly Hand-Transplanted & line sowing
- ✓ Nitrogen, Phosphorus and Potassium were applied @ 130 kg $ha^{-1}$, 60kg$ha^{-1}$ and 70 kg $ha^{-1}$ respectively. Urea, SSP and MOP were used as sources of nitrogen, phosphorus and potassium respectively.
- ✓ Dates of harvesting were
  **$T_1$** – 11.06.2018
  **$T_2$** -- 11.06.2018
  **$T_3$**–11.06.2018
  **$T_4$** -- 15.06.2018
  **$T_5$**–19.06.2018
- ✓ Data on Plant height (cm), Number of tillers per $m^2$, Number of panicles $m^{-2}$, Number of filled grains per panicle, Test weight (1000 Grain weight in g), Grain yield (t/ha), Straw yield (t/ha) were taken. Data on the above-said parameters are analysed for calculation of Harvest Index.

## CROP PRODUCTION

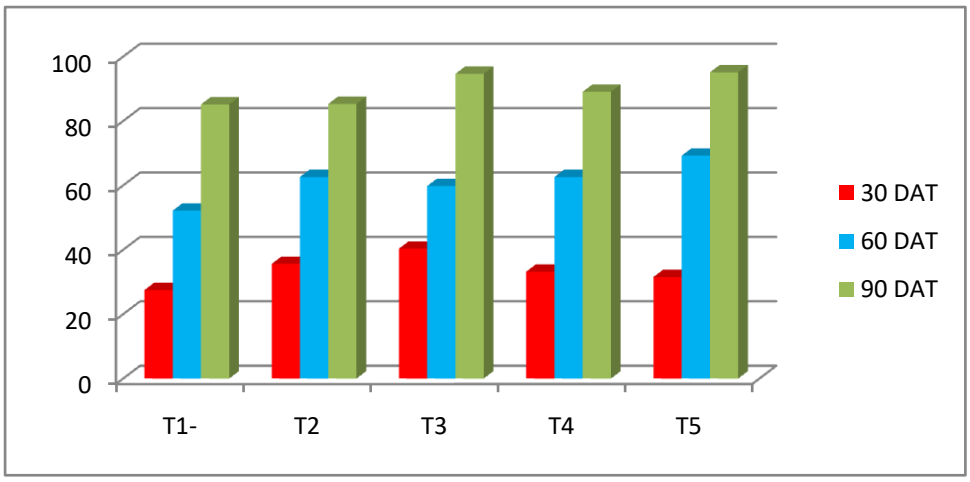



**Fig 1: Plant height (cm) at 30, 60 and 90 DAT**

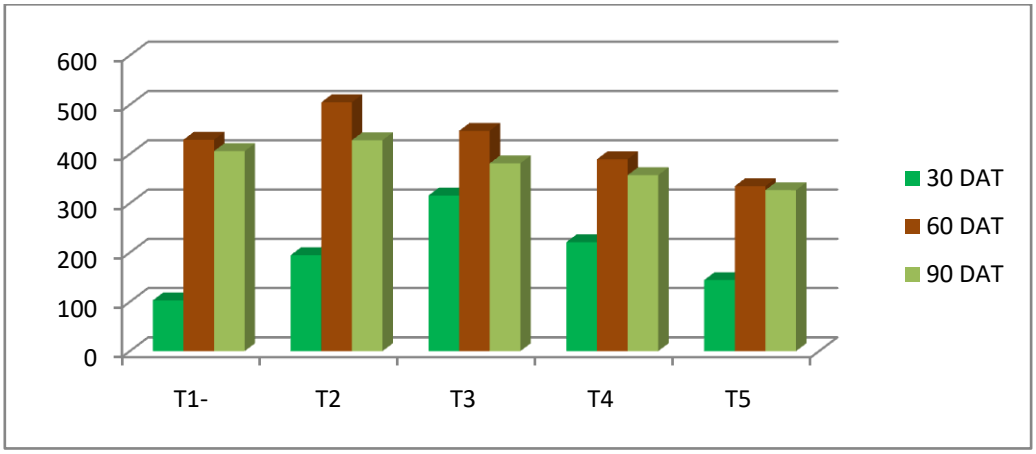



**Fig. 2: Number of tillers $m^{-2}$**

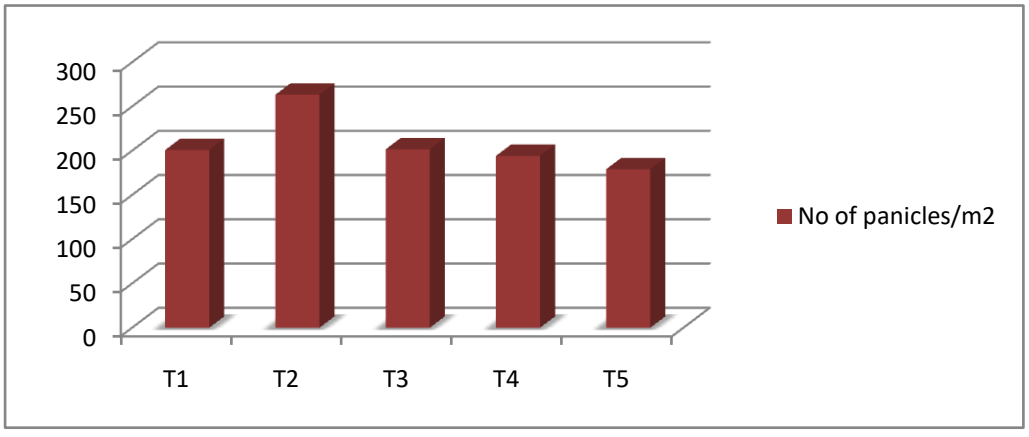



**Fig. 3: Number of panicles per $m^2$**

## CROP PRODUCTION

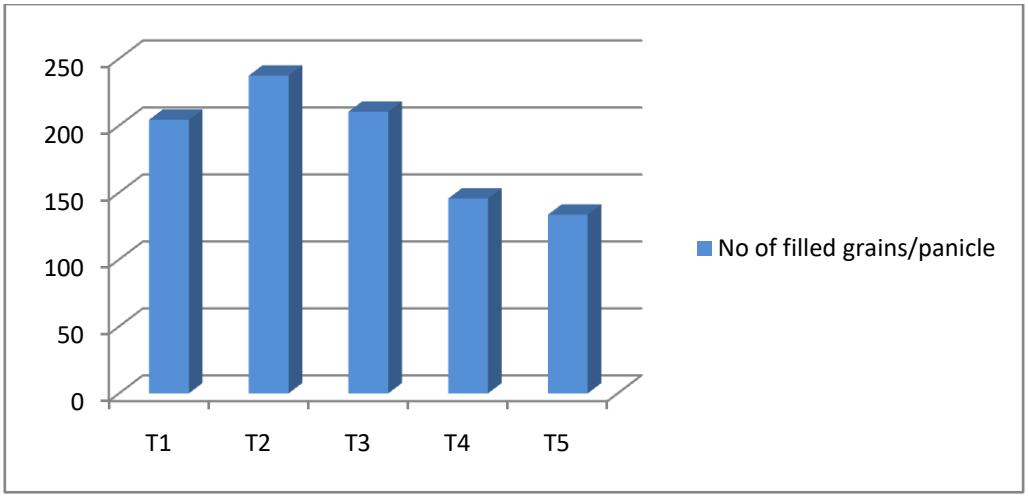



**Fig. 4: Number of grains per panicle**

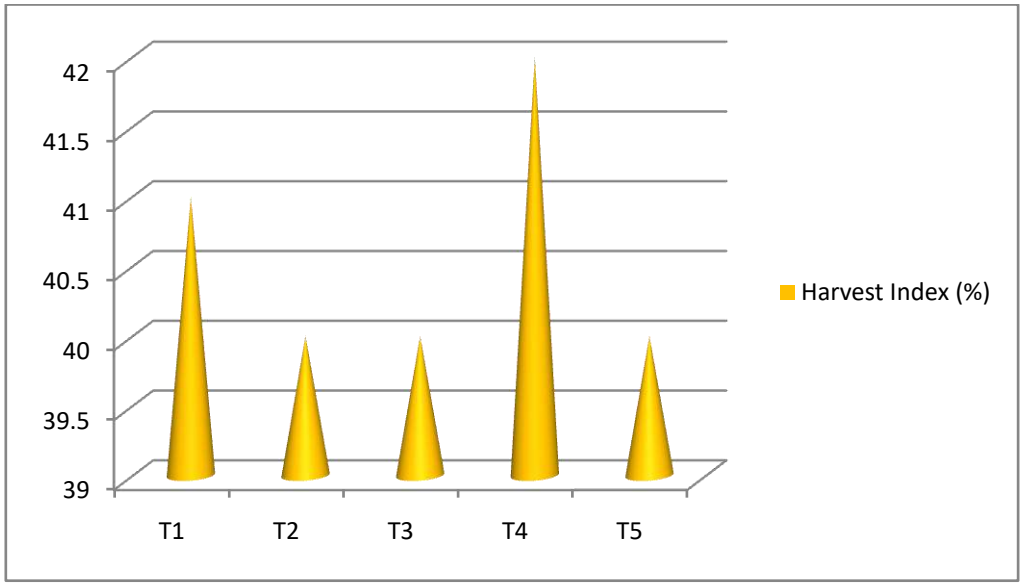



**Fig. 5: Test weight (g)**

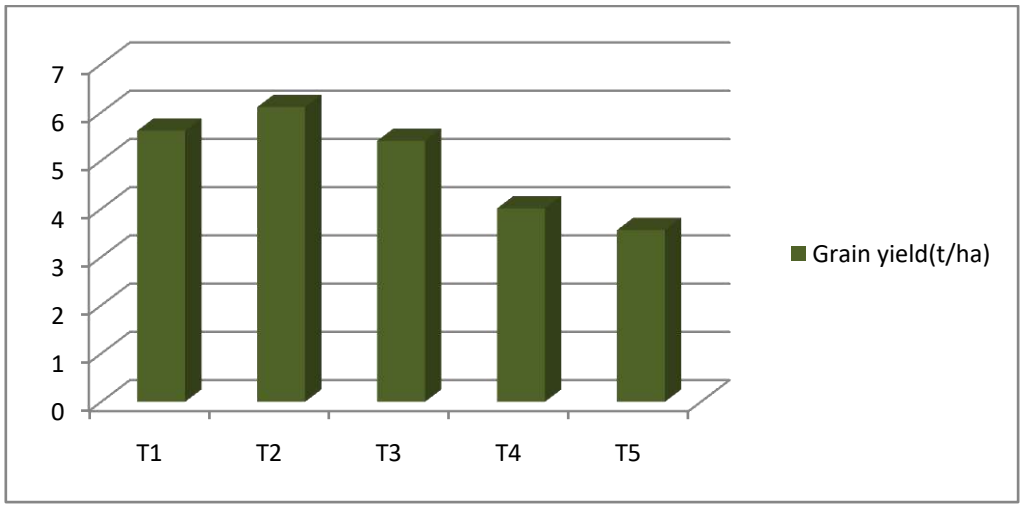



**Fig. 6: Grain yield (t/ha)**

## CROP PRODUCTION

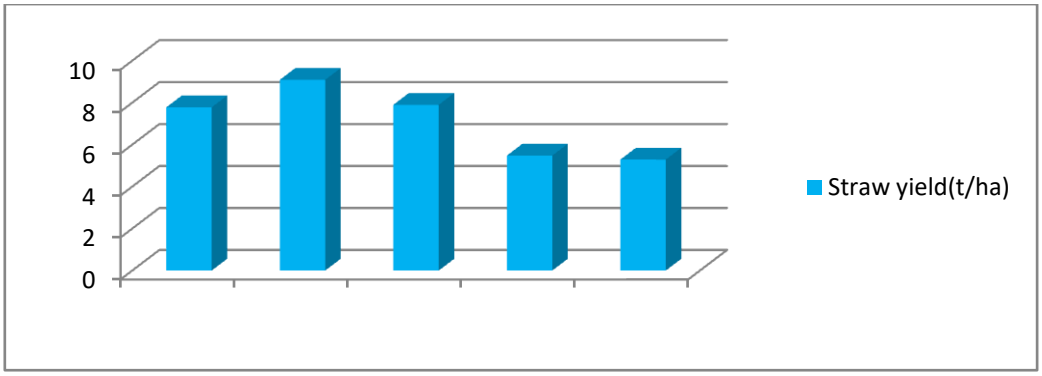



**Fig. 7: Straw yield (t/ha)**

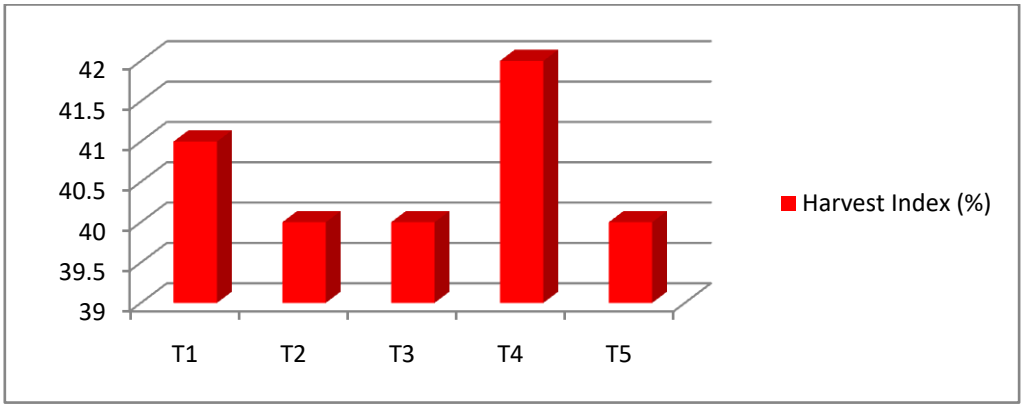



**Fig. 8: Harvest Index (%)**

**Fig.9: Field performance of rice variety "Maudamani" in different dates of planting**

# CROP PRODUCTION

**Results:**

- ✓ The crop which was transplanted on first week of January experienced poor growth in the initial days due to cold temperature of the month.
- ✓ Transplanting in the second week of January exhibited the best performance.

# CROP PROTECTION

**Title of the Programme:** ***Occurrence and Management of Major Fungal Diseases of Tomato under Terai Zone of West Bengal***

**Project code:** RRSTZ/Rabi/17-18/03

**Associate Scientist/s:** Dr. Satyajit Hembram

**Objectives**:

- ✓ To search efficient and economically profitable new fungicide as compared to others against tomato late blight disease in field conditions in Terai region of West Bengal.

**Materials:**

- ✓ Date of planting: Four (15.11.17; 01.12.17; 15.12.17; 02.01.18) for disease incidence and one (15.12.18) for evaluation for new generation fungicides ; Variety: Local Popular varietyPusa Rabi; Treatment: Seven; Replication: Three; Design: RBD

**Methodology:**

- ✓ The treatments comprised of different management practices.T1: Cholorothelonil 40% w/w + Difenconazole 4% w/w SC; T2:Sprays of mancozeb 75WP @ 2 g/L water followed by carbendazim 50 WP @ 0.5 g/L water; T3:Sprays of Cymoxanil + mancozeb @ 0.3% at the onset of the disease; T4:Sprays of Dithiocarbamate + mancozeb @ 0.3 % at the onset of the disease; T5:Ametoctradin + Dimethomorph @ 0.3% at the onset of the disease; T6:Difenconazole 25 EC @ 0.05%; T7: Control. Twofungicidalsprays applied to the all plot after disease incidence at 15 days interval and control plot sprayed with normal water.
- ✓ The mixture sprays will be apply as soon as the late blight disease occurred in tomato and subsequent two spray apply at 10 days interval with water volume of 500 litre/ha. The tomato cultivar "Patharkuchi"or other Local popular variety will be cultivated. The disease incidence will be measured in percentages of infested plants out of total plants observe:

$$\text{Percrent Disisease Incidene} = \frac{\text{No. of plants infected}}{\text{Total number of plant}} \times 100$$

Whereas disease severity was estimated by Percent Disease Index (PDI) value in 0 to 9 scale (Malcolmson, 1970).

$$\text{PDI} = \frac{\text{Sum of all numerical ratings . of plants infected}}{\text{Total plants observed x Maximum ratings scaleotal number of plant}} \times 100$$

## Results:

# CROP PROTECTION

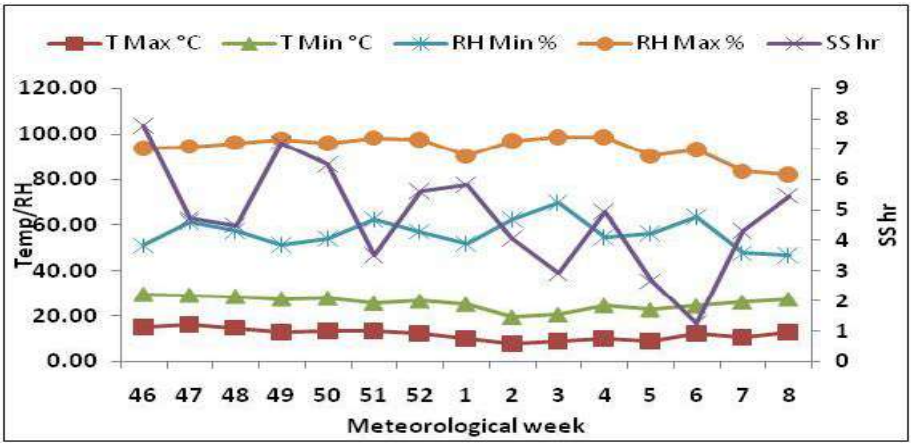



**Figure 1.Weekly average weather parameters at experimentsite during November, 2017 to February, 2018**

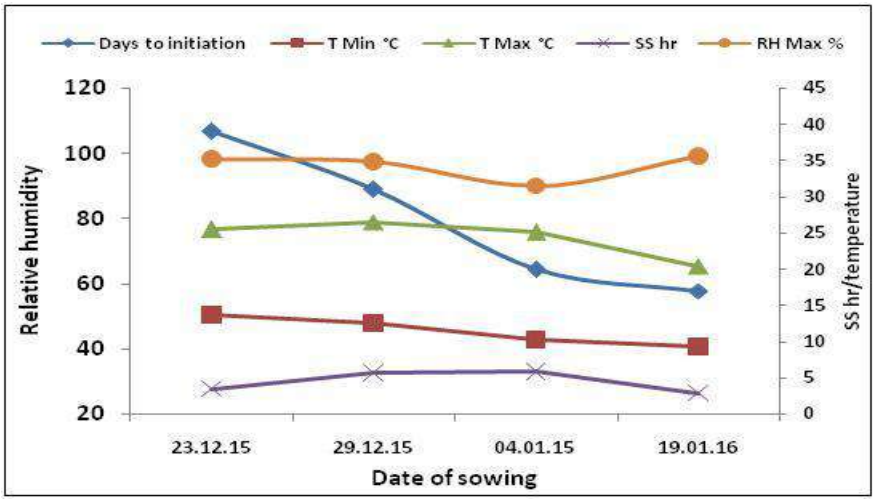



**Figure 2.Relationship between times required for disease initiation and weather parameter**

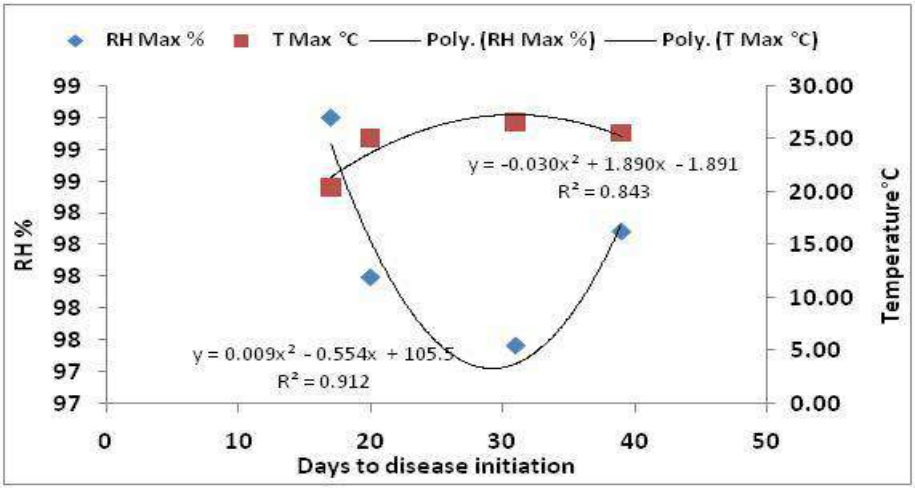



**Figure 3. Relationship between weather parameters and days to disease initiation over combined date of sowing**

# CROP PROTECTION

**Table 1. Effect of various management practices on the major foliar disease of Tomato**

| Treatment | Percent incidence of late blight | | | | |
|---|---|---|---|---|---|
| | **Before application** | **15 days after 1st application** | **15 days after 2nd application** | **30 days after 2nd application** | **% reduction over control** |
| T1 | 2.37 (8.96) | 3.41 (10.64) | 4.84 (12.71) | 6.34 (14.59) | 80.55 |
| T2 | 2.36 (8.75) | 5.46 (13.51) | 13.64 (21.67) | 15.15 (22.90) | 58.33 |
| T3 | 2.58 (9.12) | 3.77 (11.20) | 6.73 (15.04) | 8.64 (17.09) | 76.24 |
| T4 | 2.55 (9.30) | 3.83 (11.29) | 7.27 (15.64) | 9.55 (18.00) | 73.74 |
| T5 | 2.96 (10.04) | 3.52 (10.82) | 4.75 (12.59) | 6.14 (14.35) | 83.11 |
| T6 | 2.61 (9.15) | 6.09 (14.25) | 17.74 (24.91) | 19.31 (26.07) | 46.88 |
| T7 | 2.34 (8.90) | 9.26 (17.72) | 28.12 (32.02) | 36.35 (37.08) | -- |
| SEM±0.1 | 0.091 | 0.069 | 0.062 | 0.044 | -- |
| CD (0.05) | 0.280 | 0.212 | 0.192 | 0.137 | -- |

Findings :

- ✓ Among the four dates of planting, highest time (39 days) required for initiation of the late blight disease on 15.11.17 date of planting,there after the period for disease initiation decreases and lowest time required seventeen days observed during 2nd January, 18 sowing date.
- ✓ Date of initiation of the disease positively correlated with the maximum relative humidity and negatively correlated with maximum temperature and sunshine hours.
- ✓ It was observed that number of days to initiate late blight symptom on tomato was an inverse function (Y=a+bx-1) of average maximumhumidity and temperature from sowing and R2values of the equation were statistically significant at 1% level of significance.
- ✓ The late blight severity in untreated plots was 36.35%.
- ✓ Two spraying with Ametoctradin + Dimethomorph @ 0.3% showed lowest disease severity of 6.14%and 83.11% reductionin disease severity over control at 90 days after planting which was significantly at par with the Cholorothelonil 40% w/w + Difenconazole 4% w/w SC fungicide applied with disease severity of 6.34 and 80.55% reduction in late blight severity compared to untreated check.
- ✓ The result showed significant difference in disease severity (8.64%) when the Cymoxanil + mancozeb @ 0.3% fungicide was applied. The result was significantly at par with Dithiocarbamate + mancozeb @ 0.3 % (9.55%).
- ✓ Difenconazole 25 EC @ 0.05% was not comparatively effective in reducing late blight exhibiting 19.31% disease severity and only 46.88% reduction in comparison to untreated control.

# CROP PROTECTION

Plate 1. View of Experimental field

**Plate 2.** Symptoms of late blight of tomato

Recommendation :

- ✓ Two spraying with Ametoctradin + Dimethomorph @ 0.3% andCholorothelonil 40% w/w + Difenconazole 4% w/w SC fungicidescan effectively manage late blight severity.

# CROP PROTECTION

**Title of the Programme: Evaluation of different management strategies on the insect-pest complex of cabbage**

**Project code:** RRTZ/Rabi/17-18/04-01

**Associate Scientist/s:** Dr. Nilanjana Chaudhuri

**Objectives:**

- ✓ Evaluation of different IPM strategies for cabbage

**Materials:**

- ✓ Cabbage variety Green Express
- ✓ Solid and liquid indigenous microbial culture,
- ✓ Handmade botanical insecticide (Agniastra)
- ✓ NPK

**Methodology:**

- ✓ Cabbage seed was sown after treatment with indigenous microbial culture (bijamrita) in 2nd week of November and planted in the main field again upon root dipping in bijamritaduring 2nd week of December, 2017.
- ✓ The plot size was 2x3$m^2$, spacing was 45x30cm and replication was 4.

**Table 1: Treatment details**

| Management strategies | : | Details of management schedule |
|---|---|---|
| Strategy I | : | Untreated check (Fertilizer NPK at recommended dose+ no insecticide and fungicide) |
| Strategy II | : | Solid indigenous microbial culture during field preparation + Liquid indigenous microbial cultureJiwamritaat an interval of 15 days+mustard as trap crop + mulching + botanical handmade insecticide agniastra (need based) |
| Strategy III | : | Solid indigenous microbial culture during field preparation + Liquid indigenous microbial cultureJiwamritaat an interval of 15 days+ mulching +botanical insecticide agniastra |
| Strategy IV | : | Fertilizer at recommended dose+ application of neem based insecticide and fungicides |
| Strategy V | : | Fertilizer at recommended dose + mustard as trap crop+ need based application of insecticide and fungicide |
| Strategy VI | : | Fertilizer at recommended dose + need based application of insecticide and fungicide |

# CROP PROTECTION

**Results:**

**Table 2: Incidence of Insect-Pest population in different crop stages of cabbage**

| Insect-Pests | Peak Period of activity | Crop stage |
|---|---|---|
| Flea beetle *Phyllotreta*sp | 3rd week of December to 1st week of March | Vegetative and Head formation |
| Aphid *Lipaphiserysimi*Kalt | 3rd week of February to 4th week of March | Head formation |
| Diamond Back Moth *Plutellaxylostella* | 3rd week of February to 4th week of March | Head formation |

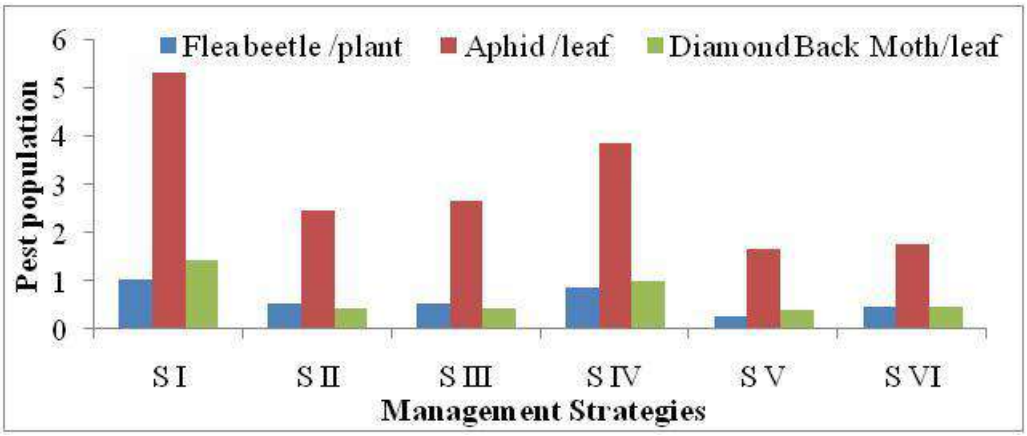



**Figure 1: Insect-Pest population infesting cabbage under different management strategies**


**Figure 2: Yield of cabbage under different management strategies**

**Findings**

- ✓ Initially the cabbage crop was infested by flea beetle. At head formation stage of the crop with the increment of temperature during 3rd week of February the population of aphid and DBM was initiated.
- ✓ The insect-pest population was higher in strategy I and the yield was lowest 26.85t/ha.

## CROP PROTECTION

- ✓ The lowest population of the all the pests was recorded in Strategy V followed by Strategy VI.
- ✓ Next to these come the strategy II and III with organic schedule.
- ✓ The yield was higher (32.42t/ha) in strategy V and it was almost at par in strategy II (31.78t/ha), III (31.52t/ha) and VI (31.24 t/ha).

**Future Scope:**

- ✓ Crop-pests module for cabbage crop may be developed based on the findings

**Recommendation:**

- ✓ Though the pest population was a little bit higher in strategies with organic schedule but the yield was at par with the recommended package of practices. Hence the strategies of organic management for insect-pest population of cabbage have proved to be better and environment friendly too.

# CROP PROTECTION

**Title of the Programme : Evaluation of conservation agricultural strategies on wheat, maize and lentil agro-ecosystem**

**Project code :** RRTZ/Rabi/17-18/04-02

**Associate Scientist/s : Dr. Nilanjana Chaudhuri**

**Objectives :** To study the impact of conservation agricultural strategies in pest population and yield of wheat, maize and lentil

**Materials (in details) :**

- ✓ Wheat variety HD2967, Maize variety DKC 9081 and Lentil variety Moitree
- ✓ Solid and liquid indigenous microbial culture
- ✓ Handmade botanical insecticide (Agniastra)
- ✓ NPK

## Methodology:

- ✓ The seeds of wheat, lentil and maize were sown in last week of December in a plot size of 3 x4 $m^2$. The spacing was 22 x 5 cm for wheat, 25 x 10 cm for lentil and 60 x 20 cm for maize.

**Table1: Details of strategies for all the three crops**

| | | |
|---|---|---|
| **Conservation strategies:** | | |
| Strategy I | : | Tillage + Seed treatment with indigenous microbial culture + Application of indigenous microbial culture as soil amendment + mulching + application of handmade botanical pesticide as and when needed |
| Strategy II | : | Tillage + Seed treatment with bio-fertilizer + Application of NPK (25% less than recommended dose) + Application of synthetic insecticides as and when needed |
| Strategy III | | Tillage + Seed treatment with bio-fertilizer + Application of indigenous microbial culture as soil amendment + mulching + Application of handmade botanical pesticide as and when needed |
| Strategy IV | | Zero Tillage + Seed treatment with bio-fertilizer + Application of NPK (25% less than recommended dose) + Application of synthetic insecticides as and when needed |
| Strategy V | | No seed treatment + Application of indigenous microbial culture as soil amendment + mulching + application of handmade botanical pesticide as and when needed |
| **Conventional strategy:** | | |
| Strategy VI | : | Farmers practice without seed treatment + recommended dose of NPK + Application of synthetic insecticides as and when needed |

## CROP PROTECTION

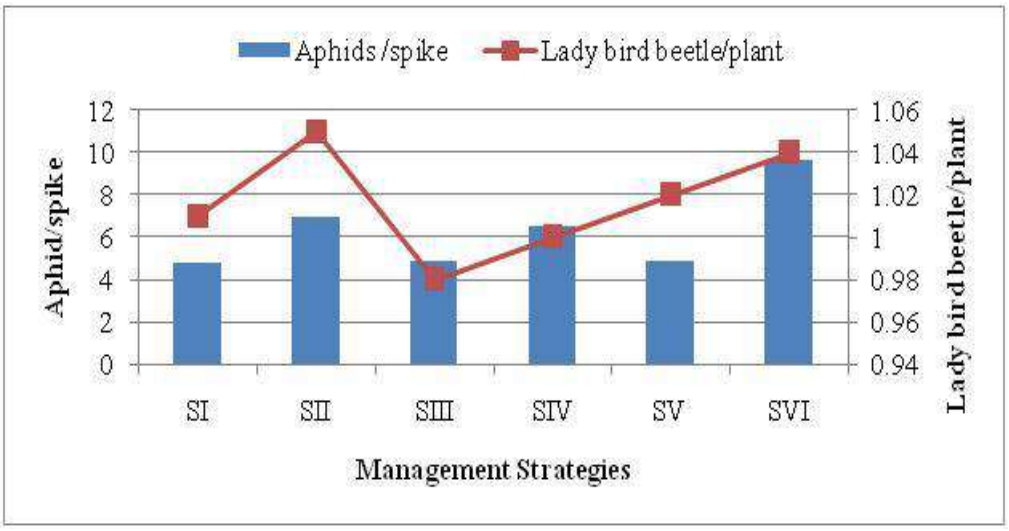



**Figure 1: Insect-pest and natural enemy population of wheat in different management strategies**

**Table 3: Performance of Wheat variety HD2967in different conservation strategies**

| Strategies | Plant height (cm) | Tillers hill$^{-1}$ | Spike length (cm) | No. of grain spike$^{-1}$ | Spike wt (g) |
|---|---|---|---|---|---|
| SI | 56.00 | 2.12 | 7.00 | 13.80 | 1.00 |
| SII | 67.32 | 4.25 | 8.57 | 37.31 | 1.39 |
| SIII | 54.31 | 2.04 | 6.95 | 13.33 | 0.90 |
| SIV | 59.80 | 4.05 | 8.56 | 31.38 | 1.20 |
| SV | 52.90 | 2.02 | 6.65 | 13.28 | 0.86 |
| SVI | 70.00 | 4.26 | 8.70 | 37.40 | 1.40 |

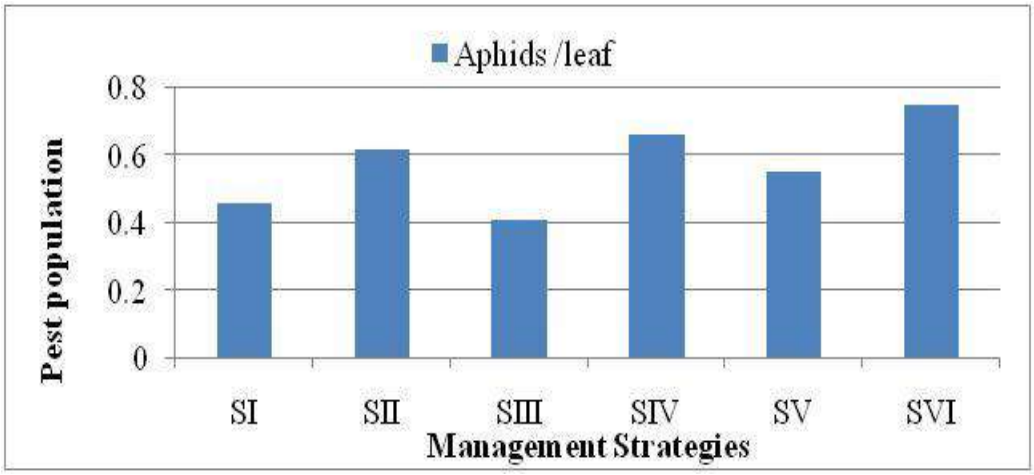



**Figure 2: Aphid population of lentil in different management strategies**

## CROP PROTECTION

**Table 4: Performance of Lentil variety Moitree WBL77in different conservation strategies**

| Strategies | Plant height (cm) | Branches plant$^{-1}$ | Seeds pod$^{-1}$ | Yield gm plant$^{-1}$ | Yield t ha$^{-1}$ |
|---|---|---|---|---|---|
| SI | 44.12 | 13.42 | 1.54 | 84.65 | 1.652 |
| SII | 43.65 | 13.05 | 1.50 | 83.75 | 1.642 |
| SIII | 44.26 | 13.40 | 1.52 | 83.25 | 1.625 |
| SIV | 42.85 | 12.56 | 1.45 | 80.02 | 1.612 |
| SV | 43.62 | 13.12 | 1.49 | 78.98 | 1.602 |
| SVI | 43.62 | 12.88 | 1.42 | 72.73 | 1.595 |

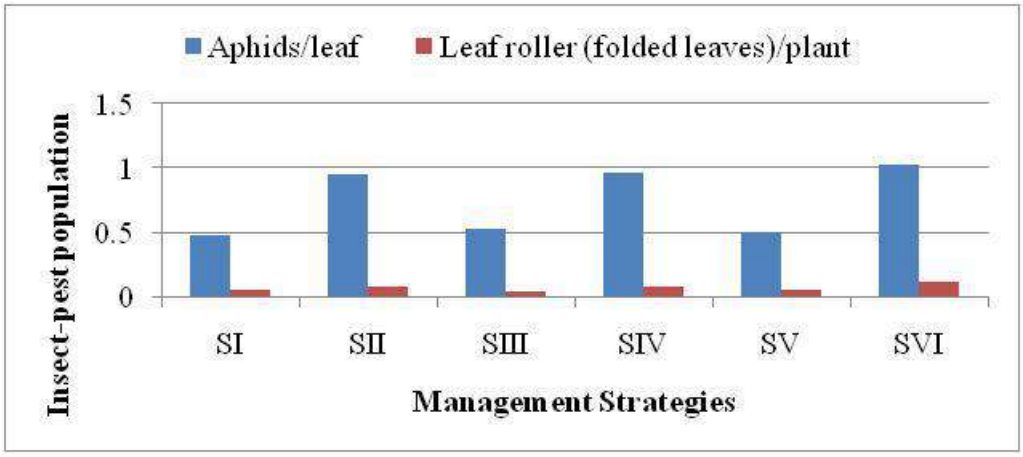



**Figure 3: Insect-pest population infesting maize in different management strategies**

**Table 5: Performance of Maize variety: DKC9081in different conservation strategies**

| Strategies | Plant height (cm) | Cob length (cm) | Grains cob $^{-1}$ | Cob weight (gm) | Yield (fresh weight) t ha$^{-1}$ |
|---|---|---|---|---|---|
| SI | 127.0 | 12.20 | 154.60 | 253.00 | 4.54 |
| SII | 239.6 | 19.47 | 285.75 | 483.20 | 16.77 |
| SIII | 128.8 | 12.80 | 154.00 | 248.80 | 3.93 |
| SIV | 223.4 | 18.20 | 284.00 | 479.40 | 12.70 |
| SV | 154.2 | 11.60 | 139.40 | 243.25 | 3.79 |
| SVI | 230.2 | 18.80 | 288.00 | 487.60 | 16.76 |

# CROP PROTECTION

**Findings:**

- ✓ The major insect infesting wheat and lentil was aphid and aphid and leaf folder in maize.
- ✓ The pest population of all the crops was lower in strategy I, III and V.
- ✓ The population was highest in conventional system strategy VI.
- ✓ The plant and yield attributing parameters of wheat were higher in strategy II and VI, lentil in strategy I and maize in strategy II and VI.
- ✓ All the parameters were found lower in strategy I, II and V.

**Future Scope:**

- ✓ Crop-pest module can be developed for holistic management of such high value crops.

**Recommendation:**

- ✓ The performance of cereal crops like wheat and maize was not satisfactory where the management was done organically which needs further study.
- ✓ In respect to legume crop lentil the organic farming system proved to the best one.

# CROP PROTECTION

**Title of the Programme*: Evaluation of different pest management modules for the insect pest complex of brinjal***

**Project code:** RRSTZ/Rabi/17-18/02

**Associate Scientist/s:** Dr. Suprakash Pal

**Objectives:**

- ✓ To find out the comparative efficacy and economies of different management module

**Materials:**

- ✓ Variety: Hybrid, SEMINIS seeds
- ✓ Design: RBD with 5 replications
- ✓ Plot size: 4 m x 3 m
- ✓ Spacing: 60 cm × 50 cm
- ✓ Treatments: Three treatments and one control

**Table 1: Description of all the treatments**

| | |
|---|---|
| M1 Biointensive management | Soil application of FYM @ 10 t/ha + Neemcake @ 500 kg/ha as basal application; Weekly clipping of infested shoots from the appearance of pests; First spray of *Verticillium lecanii* @ 4 g/l at 35 DAT for sucking pests, second spray of Multineem (0.03%, 300 ppm) @ 5 ml/l at 50 DAT; third application of *Beauveria bassiana* @ 4g/l at 60 DAT; fourth application of *Beauveria bassiana* @ 4g/l at 90 DAT |
| M2 Pesticide based IPM | Seedling root dip in Imidacloprid @ 1 ml/lit for three hours before transplanting; two rows of maize as a border crop; weekly clippings of infested shoots and fruits with the appearance of shoot and fruit borer; first application of ash @ 100 kg /ha at 35 DAT for sucking pests; second application of tobacco decoction @ 5kg/ha at 45 DAT; third application of Multineem (0.03%, 300 ppm) @ 5 ml/l at 60 DAT; fourth application of cypermethrin 10% EC @ 0.5ml/l at 90 DAT |
| M3 Pesticide intensive management | Seedling root dip in Imidacloprid @ 1 ml/lit for three hours before transplanting; First spray of Imidacloprid 17.8% SL @ 0.5 ml/lit at 35 DAT;Second spray of Abamectin 1.9% EC @ 2ml/l at 60 DAT; third spray of flubendiamide 480 SC @ 0.3 ml/l at 90 DAT |
| M4 Control | Untreated check |

**Methodology:**

## CROP PROTECTION

- ✓ The experiment was conducted during the rabi season of 2017-18 at the horticultural farm of UBKV.
- ✓ The transplanting was done on 14.12.17 and normal agronomical measures were followed to raise the crop.
- ✓ The observations were recorded at 15 days interval with the initiation of pest occurrence.
- ✓ The different treatments were applied as and when required based on the pest incidence.
- ✓ The observation on the sucking pests like aphid, jassid, whitefly and thrips were recorded selecting 3 leaves one each from top, middle and lower strata of the plant.
- ✓ The observation on sucking pests started at 30 days after transplanting and repeated after 15 days.
- ✓ Data on the fruit damage by brinjal shoot and fruit borer were recorded during the periodical harvesting of brinjal which started at 90 DAT and continued till 150 DAT.
- ✓ Harvesting was done 4 times at 15 days interval.
- ✓ Per cent fruit infestation was recorded by counting the number of infested fruits in comparison to the total number of fruits.
- ✓ Collected data were then subjected to analysis of variance (ANOVA) after appropriate transformations.
- ✓ Module wise fruit yield was recorded and increase in yield per cent over control was calculated using the formula:

$$\text{Increase (\%)} = \frac{\text{Treatment yield} - \text{Control yield}}{\text{Treatment yield}} \times 100$$

**Results:**

**Table 1: Yield and economics of different pest management modules in brinjal**

| Treat Ment modules | Yield (q/ha) | Increase in yield over control (q/ha) | Increase in yield per cent over control (%) | Value of increased yield (Rs./ha) | Cost of treatment (Rs./ha) | Net profit (Rs./ha) | Cost benefit ratio |
|---|---|---|---|---|---|---|---|
| M1 | 15.60 | 9.39 | 60.19 | 28170.00 | 33900.00 | -5730.00 | 1: - |

## CROP PROTECTION

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | 0.17 |
| M2 | 11.32+ 12.67* | 5.11+ 12.67* | 45.14 | 10220.00+ 12670.00=22890.00 | 9510.00 | 13380.00 | 1: 1.41 |
| M3 | 18.16 | 11.95 | 65.80 | 23900.00 | 9160.00 | 14740.00 | 1: 1.61 |
| M4 | 6.21 | - | - | - | | | |
| S. Em (±) | 2.47 | - | - | - | | | |
| CD (p = 0.05) | 7.71 | - | - | - | | | |

*Yield of maize as border crop (mean of 5 plots) = 12.67 q/ha

- ✓ Average cost of brinjal: Rs. 20/kg; Rs. 30/kg (organic product for biointensive management treatment); Average cost of maize: Rs. 10/kg
- ✓ Cost of FYM @ Rs. 500/ton,
- ✓ Cost of biopesticides and insecticides: Neemcake @ Rs. 5/kg, *Verticillium lecanii*@ Rs. 300/100g, *Beauveria bassiana*@ Rs. 250/100g, Multineem (0.03%, 300 ppm) @ Rs. 65/100ml, Ash @ Rs. 2/kg, Dried tobacco leaf powder @ Rs. 150/kg, Cypermethrin @ Rs. 50/100ml, Imidacloprid 17.8% SL @ Rs. 50/25ml, Abamectin 1.9% EC @ Rs. 120/100ml, Flubendiamide 480 SC @ Rs. 200/10 ml
- ✓ Spray volume: 650 lit/ha
- ✓ Labour charges for insecticidal application: Rs. 750/spray/ha

**Findings:**

- ✓ The yield varied significantly amongst different treatment modules. Significantly the highest fruit yield was obtained with the module M3 (18.16 q/ha) which was statistically at par with the modules M1 and M2.
- ✓ Per cent increase yield over control was the highest in M3 (65.80%) followed by M1 (60.19%) and M2 (45.14%).
- ✓ In the module M2 in addition to brinjal fruit yield, maize grain was harvested @ 12.67 q/ha.
- ✓ The net profit and cost benefit ratio varied depending on the cost of pesticidal application (Table 1). The highest cost benefit ratio was obtained with M3 (1: 1.61) followed by M2 (1: 1.41).
- ✓ The lower net profit/cost benefit ratio for biointensive management module (M1) could be attributable to higher cost of biopesticides thereby increasing the cost of pesticidal application.

**Future Scope**:

- ✓ Further, other different type of biopesticides and organic amendments may be tested for their sustainability and economic viability for the management of brinjal pest complex.

## CROP PROTECTION

- ✓ In future, the experiment may be repeated for assessing its accuracy and validation of the pest management module should be done in farmers field on a large scale basis.

**Recommendation**:

- ✓ Instead of producing higher yield of brinjal, the biointensive pest management module resulted in lower cost benefit ratio mainly due to higher price of biopesticides and organic amendments. Therefore, the pesticide based IPM module may be recommended which resulted in comparatively lower crop yield but returned modest cost benefit ratio (1: 1.41) compared to totally pesticide based module (1: 1.61). IPM module with thoughtful integration of eco-friendly insecticides would be economically more viable as compared to biopesticide based pest management module.
- ✓ Earlier, Satpathi*et al*. (2016) also concluded that IPM modules with eco-friendly pesticides could be considered as an effective and economic approach of insect pest management in cowpea ecosystem under terai agroecological conditions of West Bengal.

## HORTICULTURE

**Title of the programme:** ***Effect of sowing time and variety on the Growth, yield and quality of bush type vegetable French bean***

**Project Code:** RRSTZ/Rabi/2017-18/07

**Associate Scientist/s :** Dr. Suchand Datta

**Objective:**

- ✓ To study the performances of bush type French bean (*Phaseolus vulgaris* L.) varieties under different dates of sowing with respect to growth, fresh pod yield and quality

**Materials:**

- ✓ Three numbers of French bean varieties.

**Table 1: Details of French bean genotypes**

| Serial Number | Name of the Variety | Type of the Variety | Source |
|---|---|---|---|
| **1** | Falguni | Bush type | Monsanto Holdings Pvt. Ltd. |
| **2** | Arka Komal | Bush type, | National Seeds Corporation, Pusa complex, New Delhi-110012. |
| **3** | Nandini | Bush type | Kulak, New Delhi. |

**Methodology:**

- ✓ Design of the Experiments: Factorial Randomized Block design
- ✓ Replications: 3
- ✓ Factor A: 5 Sowing time (S)
  - i) 1st November ($S_1$)
  - ii) 16th November ($S_2$)
  - iii) 1st December ($S_3$)
  - iv) 16th December ($S_4$)
  - v) 31st December ($S_5$)
- ✓ Factor B : Variety : 3 umbers of variety (V)
  - i) Falguni ($V_1$)
  - ii) Arka Komal ($V_2$)
  - iii) Nandini ($V_3$)
- ✓ Spacing: 45 cm X 15 cm.
- ✓ Common fertilizer dose: 80:40:40 @ N: $P_2O_5$ :$K_2O$ kg/ha.
- ✓ Farm Yard Manure (FYM): 15 tonnes/ha.
- ✓ Time of sowing: Middle of November of each year.
- ✓ Plot Size: 1.8m x 1.5m.
- ✓ Year of Study: *Rabi* season of 2017-18.

## HORTICULTURE

### Results:

**Table 1: Effect of sowing time and variety on growth parameter of French bean**

| | Plant height (cm) | | | | Primary branches/plant | | | |
|---|---|---|---|---|---|---|---|---|
| | **$V_1$** | **$V_2$** | **$V_3$** | **Mean** | **$V_1$** | **$V_2$** | **$V_3$** | **Mean** |
| **$S_1$** | 42.06 | 40.93 | 41.33 | 41.44 | 5.40 | 5.13 | 6.80 | 5.78 |
| **$S_2$** | 37.19 | 37.71 | 36.28 | 37.06 | 6.42 | 5.35 | 7.43 | 6.40 |
| **$S_3$** | 37.14 | 36.50 | 32.59 | 35.41 | 5.17 | 6.80 | 7.27 | 6.41 |
| **$S_4$** | 32.92 | 31.73 | 31.60 | 32.08 | 7.07 | 5.80 | 6.63 | 6.50 |
| **$S_5$** | 28.92 | 27.53 | 25.99 | 27.48 | 5.35 | 5.58 | 5.62 | 5.52 |
| **Mean** | 35.65 | 34.88 | 33.56 | | 5.88 | 5.73 | 6.75 | |
| | S | V | VXS | | S | V | VXS | |
| **SEm±** | 0.92 | 0.71 | 1.59 | | 0.33 | 0.26 | 0.57 | |
| **CD (P=0.05)** | 2.67 | N.S. | N.S. | | N.S. | 0.74 | N.S. | |

$S_1$ = 1st November sowing, $S_2$ =16th November, $S_3$ =1st December, $S_4$ = 16th December and $S_5$ =31st December; $V_1$= Falguni, $V_2$ = Arka Komal and $V_3$ = Nandini ;N.S. = Non significant

**Table 2: Effect of sowing time and variety on pod length and width of French bean**

| | Pod length (cm) | | | | Pod width (cm) | | | |
|---|---|---|---|---|---|---|---|---|
| | **$V_1$** | **$V_2$** | **$V_3$** | **Mean** | **$V_1$** | **$V_2$** | **$V_3$** | **Mean** |
| **$S_1$** | 12.67 | 13.74 | 13.58 | 13.30 | 0.82 | 1.25 | 0.89 | 0.99 |
| **$S_2$** | 13.06 | 14.10 | 13.48 | 13.55 | 0.86 | 1.16 | 0.83 | 0.95 |
| **$S_3$** | 11.68 | 14.04 | 12.84 | 12.85 | 0.88 | 1.12 | 0.82 | 0.94 |
| **$S_4$** | 11.36 | 12.92 | 12.27 | 12.81 | 0.82 | 1.05 | 0.80 | 0.89 |
| **$S_5$** | 10.85 | 11.93 | 11.67 | 11.48 | 0.79 | 1.01 | 0.78 | 0.86 |
| **Mean** | 11.93 | 13.35 | 12.77 | | 0.84 | 1.12 | 0.82 | |
| | S | V | VXS | | S | V | VXS | |
| **SEm±** | 0.21 | 0.17 | 0.38 | | 0.02 | 0.2 | 0.03 | |
| **CD (P=0.05)** | 0.64 | 0.49 | N.S. | | 0.06 | 0.04 | N.S. | |

$S_1$ = 1st November sowing, $S_2$ =16th November, $S_3$ =1st December, $S_4$ = 16th December and $S_5$ =31st December; $V_1$= Falguni, $V_2$ = Arka Komal and $V_3$ = Nandini ;N.S. = Non significant

**Table-3: Effect of sowing time and variety on pod weight and width pods per plant of French bean**

| | Individual pod weight (g) | | | | Pods/Plant | | | |
|---|---|---|---|---|---|---|---|---|
| | **$V_1$** | **$V_2$** | **$V_3$** | **Mean** | **$V_1$** | **$V_2$** | **$V_3$** | **Mean** |
| **$S_1$** | 4.70 | 5.11 | 4.99 | 4.94 | 24.13 | 24.47 | 28.53 | 25.71 |
| **$S_2$** | 4.84 | 5.70 | 5.10 | 5.22 | 28.60 | 25.33 | 27.20 | 27.04 |
| **$S_3$** | 4.34 | 5.30 | 3.99 | 4.54 | 22.93 | 21.33 | 25.93 | 23.40 |
| **$S_4$** | 3.74 | 4.86 | 3.73 | 4.11 | 21.20 | 18.20 | 15.60 | 18.33 |
| **$S_5$** | 2.95 | 4.41 | 3.34 | 3.96 | 14.53 | 11.40 | 13.20 | 13.04 |
| **Mean** | 4.12 | 5.08 | 4.25 | | 22.28 | 20.15 | 22.09 | |
| | S | V | VXS | | S | V | VXS | |
| **SEm±** | 0.13 | 0.10 | 0.22 | | 0.59 | 0.46 | 1.03 | |
| **CD (P=0.05)** | 0.37 | 0.29 | N.S. | | 1.73 | 1.34 | 2.99 | |

$S_1$ = 1st November sowing, $S_2$ =16th November, $S_3$ =1st December, $S_4$ = 16th December and $S_5$ =31st December; $V_1$= Falguni, $V_2$ = Arka Komal and $V_3$ = Nandini ;N.S. = Non significant

**Table- :** 4 **Effect of sowing time and variety on yield of French bean**

## HORTICULTURE

| | Yield/Plant (g) | | | | Yield (t/ha) | | | |
|---|---|---|---|---|---|---|---|---|
| | **$V_1$** | **$V_2$** | **$V_3$** | **Mean** | **$V_1$** | **$V_2$** | **$V_3$** | **Mean** |
| **$S_1$** | 104.44 | 121.76 | 125.13 | 117.11 | 17.64 | 20.29 | 21.27 | 19.73 |
| **$S_2$** | 120.75 | 132.76 | 127.96 | 127.16 | 19.95 | 24.20 | 22.46 | 22.20 |
| **$S_3$** | 90.34 | 112.24 | 106.76 | 103.11 | 15.23 | 19.21 | 18.26 | 17.57 |
| **$S_4$** | 70.91 | 86.1 | 68.92 | 75.31 | 12.05 | 14.05 | 11.65 | 12.58 |
| **$S_5$** | 44.19 | 49.07 | 45.41 | 46.22 | 7.87 | 8.71 | 7.50 | 8.03 |
| **Mean** | 86.13 | 100.39 | 94.84 | | 14.55 | 17.29 | 16.23 | |
| | S | V | VXS | | S | V | VXS | |
| **SEm±** | 3.01 | 2.33 | 6.33 | | 0.39 | 0.34 | 0.68 | |
| **CD (P=0.05)** | 10.64 | 6.80 | 18.43 | | 1.14 | 0.89 | 1.99 | |

$S_1$ = 1st November sowing, $S_2$ =16th November, $S_3$ =1st December, $S_4$ = 16th December and $S_5$ =31st December; $V_1$= Falguni, $V_2$ = Arka Komal and $V_3$ = Nandini ;N.S. = Non significant

**Table** 5: **Effect of sowing time and variety on protein (%) of of French bean**

| | Protein (%) of fresh beans | | | |
|---|---|---|---|---|
| | **$V_1$** | **$V_2$** | **$V_3$** | **Mean** |
| **$S_1$** | 2.20 | 1.67 | 1.76 | 1.88 |
| **$S_2$** | 2.21 | 1.70 | 1.76 | 1.89 |
| **$S_3$** | 2.17 | 1.65 | 1.71 | 1.84 |
| **$S_4$** | 2.09 | 1.59 | 1.60 | 1.76 |
| **$S_5$** | 2.04 | 1.57 | 1.55 | 1.72 |
| **Mean** | 2.14 | 1.64 | 1.68 | |
| | S | V | VXS | |
| **SEm±** | 0.02 | 0.01 | 0.03 | |
| **CD (P=0.05)** | 0.05 | 0.04 | N.S. | |

$S_1$ = 1st November sowing, $S_2$ =16th November, $S_3$ =1st December, $S_4$ = 16th December and $S_5$ =31st December; $V_1$= Falguni, $V_2$ = Arka Komal and $V_3$ = Nandini ;N.S. = Non significant

**Photograph**

**Experimental field : RRSTZ/Rabi/2017-18/07**


**Variety Arka Komal at 16th November Sowing**

**HORTICULTURE**

| | |
|---|---|
|   |   |
| **Variety Falguni at 16th November Sowing** | **Variety Falguni at 1st November Sowing** |

**Findings:**

- ✓ Plant height, pod length, pod width, individual pod weight, number of pod, yield and protein content of fresh French beans varied significantly with respect to the sowing time.
- ✓ Irrespective of the sowing time, all the parameters except plant height varied significantly among the varieties.
- ✓ Among the varieties, the highest pod yield was recorded in Arka Komal (17.29 t/ha) followed by Nandini (16.23 t/ha) and lowest yield was recorded in the control variety i.e. in Falguni (14.55 t/ha).
- ✓ Among the sowing dates, significantly the highest yield (22.20 t/ha) was recorded in 16th November sowing followed by 1st November sowing (19.73 t/ha) and 1st December sowing (17.57 t/ha).
- ✓ Considering the interaction effect, it was evident that the highest pod yield was recorded at 16th November sowing with Arka Komal variety followed by same sowing date with the variety Nandini. Irrespective of sowing time, the highest protein content was recorded in Falguni (2.14%).

**Future Scope:**

- ✓ Nutrient management and crop protection trial may be under taken in future.

**Recommendation:**

- ✓ Considering the interaction effect, it was evident that the highest pod yield was recorded at 16th November sowing with Arka Komal variety followed by same sowing date with the variety Nandini. Irrespective of sowing time, the highest protein content was recorded in Falguni (2.14%)

## SOCIAL SCIENCE

**Title of the Programme:** ***Long Term time series analysis of data on area, production and productivity of oil seed crops and meteorological parameters (Temperature, Rainfall and Sunshine hour) of Terai Agro-climatic zone of West Bengal***

**Project code:** RRSTZ/Rabi/17-18/11

**Associate Scientist:** Dr.ArunavaGhosh

**Objectives:**

- ✓ Identification of best fitted time series model on area, production and productivity of oil seed crops and meteorological parameters under Terai Agro-climatic zone of West Bengal
- ✓ Forecasting the future values using identified best fitted model

**Materials:**

- ✓ The annual data on oil seed cultivated area and production for the period from 1977-78 to 2014-15 in Coochbehar district of West Bengal collected from Statistical Abstract, Govt. of West Bengal were used for forecasting the future values using Auto Regressive Integrated Moving Average (ARIMA) models by employing the three stages (identification, estimation and diagnostic checking) iterative procedure (Box and Jenkins, 1976).
- ✓ Daily rainfall data commencing from 1969 to 2015 for Coochbeharwere collected from IMD, Pune.

**Methodology:**

- ✓ A time series variable is considered for searching a good model when the variable satisfied important criteria, i.e., the series be strictly stationary under normality assumption, (stationarity implying the means, variances and autocorrelations be essentially constant over time).
- ✓ A non-stationary time series variable is to made stationary by suitable transformation before employing it for ARIMA modelling.
- ✓ An Univariate Box Jenkins (UBJ) model is represented by ARIMA (p,d,q) where p, d, q are the parameters (‘p’ is the order of AR process, ‘d’ is the order of differencing and ‘q’ is the order of MA process) to be estimated at which the model possesses a high predictive power and predicts the future values with high precision.
- ✓ The optimum value of p,d,q are obtained by employing the iterative finite-unconditional-least-squares method to the family of ARIMA models suspected at the identification stage. Each p+q coefficients is estimated and then tested for its

significance. The root mean square error (RMSE), mean absolute percentage error (MAPE) and normalized Basian Information Criteria (BIC) are computed.

- ✓ Adequate models are obtained by examining independence, normality, zero mean and constant variance of the residuals.
- ✓ Among all sets of models, the best fitted ARIMA is identified by judicious comparison taking into consideration of minimum value of RMSE, MAE, MAPE, BIC and maximum value of $R^2$. The Absolute Relative Percent Forecast Error (ARPFE) is also computed for model validation.

**Results:**

- ✓ The results, in Table 2 reveals that in case of oilseed production variable ARIMA(2,1,2) is found to be the best model having smaller RMSE, MAE, MAPE and normalised BIC values.
- ✓ In case of oilseed cultivated area variable (Table 5), the best model is ARIMA(1,1,2).
- ✓ Best fitted models are also subjected to diagnostic checking on their residuals and the results possess all the desired properties.
- ✓ The best fitted model, ARIMA(2,1,2) for oilseed production variable (Table 3) is also found to possess a good predictive power (value of ARPFE) of about 4.16 (for the year 2013-14) and 6.90 (for the year 2014-15) respectively.
- ✓ Similarly, best fitted model, ARIMA(1,1,2) for oilseed cultivated area is also found to possess a very good predictive power (less than 4.5 percent) for both the years.
- ✓ The best fitted model shows that oil seed production (Table-4) and cultivated area (Table 6) for the year 2024-25 would be about 12.4 thousand tonnes (42.5% increase over 2014-15) and 20.1 thousand hectares (28.8% increase over 2014-15) respectively.
- ✓ Five moderate (1978, 1979, 2006, 2013 and 2014) and one severe drought years (2010) are noticed (Table-9).
- ✓ ARIMA (1,0,2) is found to be the best for prediction of yearly rainfall in Coochbehar District (Table-11).
- ✓ Model shows that yearly rainfall for the year 2018, 2019 and 2020 would be 2941.51mm, 2961.24mm and 2916.69 respectively (Table-12).

## SOCIAL SCIENCE

### Table 1: Oil seed cultivated Area and Production in Coochbehar District

| Year | Area (,000 ha) | Production (,000 tonnes) | Year | Area (,000 ha) | Production (,000 tonnes) |
|---|---|---|---|---|---|
| 1977-78 | 5.8 | 1.8 | 1996-97 | 14.2 | 8.1 |
| 1978-79 | 10.4 | 3.2 | 1997-98 | 14.0 | 6.1 |
| 1979-80 | 10.2 | 2.5 | 1998-99 | 12.9 | 6.7 |
| 1980-81 | 10.0 | 2.9 | 1999-2000 | 14.0 | 9.1 |
| 1981-82 | 9.9 | 3.7 | 2000-01 | 12.6 | 7.7 |
| 1982-83 | 14.2 | 4.8 | 2001-02 | 13.8 | 7.2 |
| 1983-84 | 13.6 | 4.0 | 2002-03 | 15.3 | 6.9 |
| 1984-85 | 11.8 | 2.8 | 2003-04 | 29.6 | 16.1 |
| 1985-86 | 11.1 | 3.4 | 2004-05 | 30.0 | 13.4 |
| 1986-87 | 13.7 | 4.3 | 2005-06 | 22.5 | 12.1 |
| 1987-88 | 11.2 | 3.4 | 2006-07 | 22.6 | 12.0 |
| 1988-89 | 14.1 | 8.0 | 2007-08 | 20.8 | 9.6 |
| 1989-90 | 12.7 | 6.3 | 2008-09 | 14.6 | 6.2 |
| 1990-91 | 10.3 | 5.3 | 2009-10 | 12.2 | 6.3 |
| 1991-92 | 11.8 | 8.0 | 2010-11 | 14.5 | 8.2 |
| 1992-93 | 11.8 | 6.1 | 2011-12 | 15.0 | 7.5 |
| 1993-94 | 13.6 | 7.8 | 2012-13 | 14.5 | 6.5 |
| 1994-95 | 13.1 | 6.9 | 2013-14 | 15.2 | 10.8 |
| 1995-96 | 13.2 | 6.2 | 2014-15 | 15.6 | 8.7 |

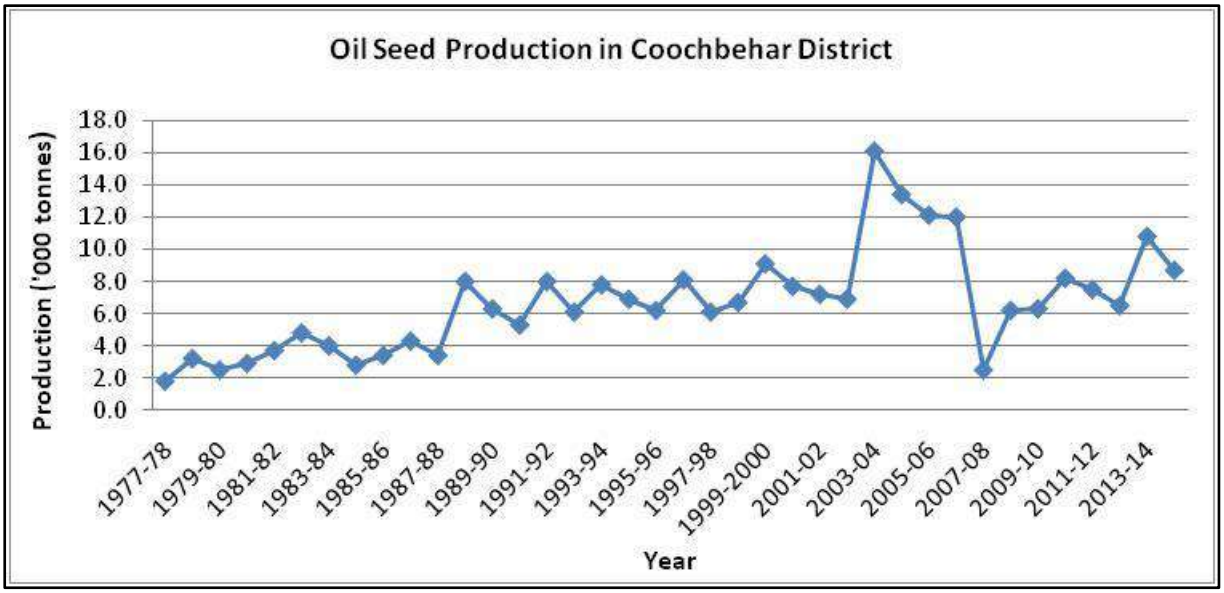



**Figure 1: Diagram of Oil Seed Production values (1977-78 to 2014-15)**

## SOCIAL SCIENCE

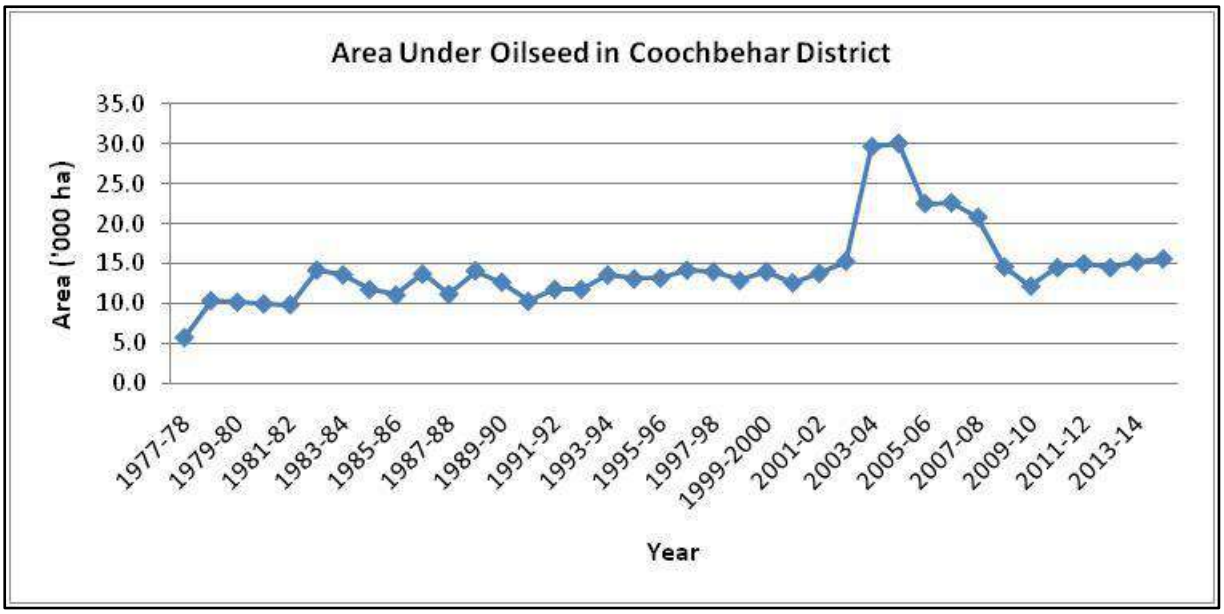



**Figure 2: Diagram of Oil Seed Cultivated Area values (1977-78 to 2014-15)**

**Table 2: Model Comparison of Oilseed Production ('000 tonnes) in Coochbehar District UnderTerai Zone of West Bengal**

| Model | $R^2$ | RMSE | MAPE | MAE | BIC |
|---|---|---|---|---|---|
| ARIMA(1,0,0) | 0.468 | 2.402 | 27.908 | 1.452 | 2.051 |
| ARIMA(0,0,1) | 0.453 | 2.435 | 28.545 | 1.524 | 2.079 |
| ARIMA(1,0,1) | 0.468 | 2.438 | 27.861 | 1.444 | 2.180 |
| ARIMA(1,1,1) | 0.460 | 2.417 | 28.220 | 1.513 | 2.171 |
| ARIMA(1,1,2) | 0.511 | 2.337 | 25.538 | 1.437 | 2.206 |
| ARIMA(2,1,1) | 0.459 | 2.458 | 28.179 | 1.507 | 2.306 |
| **ARIMA(2,1,2)** | **0.514** | **2.370** | **25.453** | **1.392** | **2.135** |
| ARIMA(1,2,1) | 0.229 | 2.880 | 32.665 | 1.688 | 2.531 |
| ARIMA(1,2,2) | 0.277 | 2.838 | 30.287 | 1.521 | 2.604 |
| ARIMA(2,2,2) | 0.253 | 2.935 | 31.721 | 1.624 | 2.776 |

**Table 3: Validation for Oilseed Production, ARIMA (2,1,2)**

| Year | Observed Value ('000 tonnes) | Predicted Value ('000 tonnes) | Residual | Absolute Relative PercentForecast Error [ARPFE(%)] |
|---|---|---|---|---|
| 2013-14 | 10.8 | 11.25 | 0.45 | 4.16 |
| 2014-15 | 8.7 | 9.3 | 0.6 | 6.90 |

**Table 4: Oilseed Production Forecast for Ten Years, ARIMA (2,1,2)**

| **Year** | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 | 2020-21 | 2021-22 | 2022-23 | 2023-24 | 2024-25 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Forecast Value ('000 tonnes)** | 9.5 | 9.7 | 9.6 | 9.8 | 10.2 | 10.8 | 11.8 | 11.3 | 11.9 | 12.4 |

## SOCIAL SCIENCE

**Table 5: Model Comparison of Oilseed Area (‘000 ha) in Coochbehar District UnderTerai Zone of West Bengal**

| Model | $R^2$ | RMSE | MAPE | MAE | BIC |
|---|---|---|---|---|---|
| ARIMA(1,0,0) | 0.606 | 3.228 | 12.966 | 1.889 | 2.642 |
| ARIMA(0,0,1) | 0.597 | 3.267 | 14.542 | 2.112 | 2.666 |
| ARIMA(1,0,1) | 0.635 | 3.158 | 13.122 | 1.862 | 2.698 |
| ARIMA(1,1,1) | 0.525 | 3.499 | 13.805 | 2.084 | 2.911 |
| **ARIMA(1,1,2)** | **0.597** | **3.277** | **12.809** | **1.918** | **2.582** |
| ARIMA(2,1,1) | 0.543 | 3.489 | 13.699 | 2.056 | 3.007 |
| ARIMA(2,1,2) | 0.595 | 3.340 | 12.821 | 1.911 | 3.022 |
| ARIMA(1,2,1) | 0.452 | 3.777 | 16.239 | 2.422 | 3.073 |
| ARIMA(1,2,2) | 0.464 | 3.800 | 15.567 | 2.369 | 3.189 |
| ARIMA(2,2,2) | 0.475 | 3.826 | 15.697 | 2.350 | 3.306 |

**Table 6: Validation for Oilseed Area, ARIMA (1,1,2)**

| Year | Observed Value(‘000 ha) | Predicted Value (‘000 ha) | Residual | Absolute Relative Percent Forecast Error [ARPFE(%)] |
|---|---|---|---|---|
| 2013-14 | 15.2 | 15.7 | 0.5 | 3.29 |
| 2014-15 | 15.6 | 16.3 | 0.7 | 4.49 |

**Table 7: Oilseed Area Forecast for Ten Years, ARIMA (1,1,2)**

| **Year** | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 | 2020-21 | 2021-22 | 2022-23 | 2023-24 | 2024-25 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Forecast Value (‘000 ha)** | 16.1 | 16.6 | 17.2 | 17.7 | 18.1 | 18.5 | 18.4 | 18.1 | 19.6 | 20.1 |

**Table 8: Yearly Rainfall in Coochbehar**

| Year | Total Rainfall (mm) | Year | Total Rainfall (mm) | Year | Total Rainfall (mm) |
|---|---|---|---|---|---|
| 1969 | 3717.7 | 1985 | 3908.92 | 2001 | 2562.5 |
| 1970 | 3412.5 | 1986 | 2730.8 | 2002 | 2976.6 |
| 1971 | 3922.407 | 1987 | 4193.5 | 2003 | 3486.8 |
| 1972 | 2648.4 | 1988 | 4885.1 | 2004 | 3521.7 |
| 1973 | 3409.4 | 1989 | 3650.6 | 2005 | 3710 |
| 1974 | 4319.7 | 1990 | 3383.6 | 2006 | 2568.3 |
| 1975 | 3272.54 | 1991 | 2968.7 | 2007 | 2808.7 |
| 1976 | 2562.6 | 1992 | 2566.9 | 2008 | 3941.8 |
| 1977 | 3313.2 | 1993 | 2350 | 2009 | 2739.2 |
| 1978 | 2308.2 | 1994 | 2780 | 2010 | 1529.5 |
| 1979 | 2468.4 | 1995 | 4351.4 | 2011 | 2853.5 |
| 1980 | 2511.7 | 1996 | 3624.2 | 2012 | 3437 |
| 1981 | 3040.9 | 1997 | 3539.4 | 2013 | 2451.5 |
| 1982 | 3794.7 | 1998 | 4469.7 | 2014 | 2142.4 |
| 1983 | 3657.1 | 1999 | 4074 | 2015 | 3062.5 |
| 1984 | 4638 | 2000 | 3269.3 | | |

## SOCIAL SCIENCE

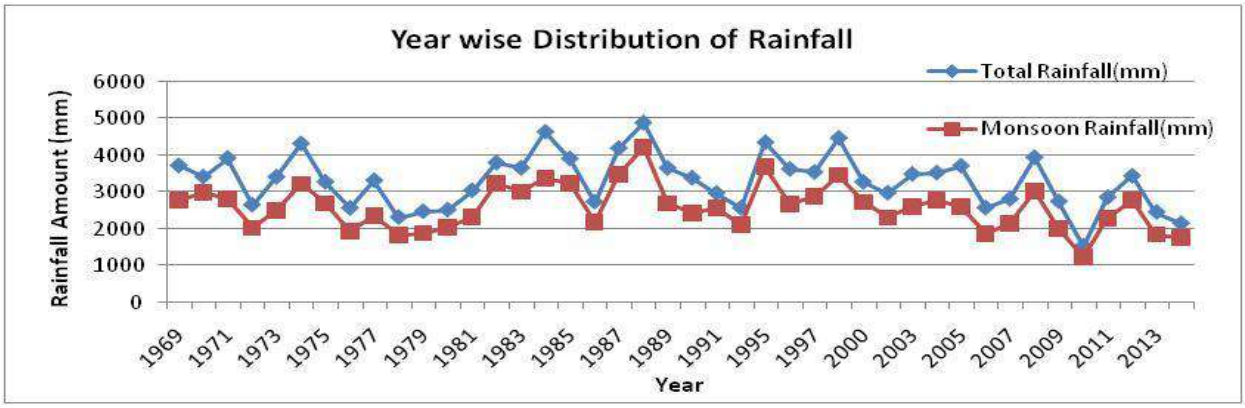



**Figure 3: Diagram of Annual and MonsoonRainfall in Coochbehar (1969 to 2014)**

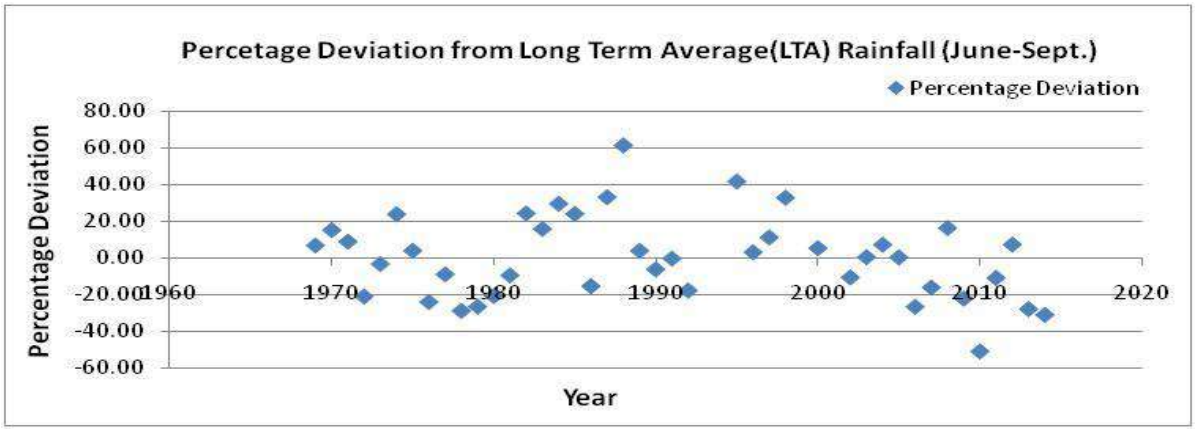



**Figure 4: Diagram of PercentDeviation of Rainfall**

**Table 9: Drought category and parent deviation of rainfall in monsoon season**

| Year | % Deviation | Drought Category | Year | % Deviation | Drought Category |
|---|---|---|---|---|---|
| 1969 | 6.84 | | 1990 | -6.17 | |
| 1970 | 15.17 | | 1991 | -0.29 | |
| 1971 | 8.92 | | 1992 | -17.62 | |
| 1972 | -20.86 | | 1995 | 41.57 | |
| 1973 | -3.22 | | 1996 | 3.11 | |
| 1974 | 23.76 | | 1997 | 11.23 | |
| 1975 | 4.03 | | 1998 | 32.75 | |
| 1976 | -23.89 | | 2000 | 5.34 | |
| 1977 | -8.86 | | 2002 | -10.50 | |
| 1978 | -28.61 | Moderate Drought | 2003 | 0.49 | |
| 1979 | -26.36 | Moderate Drought | 2004 | 7.23 | |
| 1980 | -20.59 | | 2005 | 0.38 | |
| 1981 | -9.41 | | 2006 | -26.49 | Moderate Drought |
| 1982 | 24.21 | | 2007 | -15.99 | |
| 1983 | 15.81 | | 2008 | 16.31 | |
| 1984 | 29.47 | | 2009 | -22.00 | |
| 1985 | 29.97 | | 2010 | -50.68 | Severe Drought |
| 1986 | -15.24 | | 2011 | -10.77 | |
| 1987 | 33.03 | | 2012 | 7.31 | |
| 1988 | 61.15 | | 2013 | -27.68 | Moderate Drought |
| 1989 | 3.98 | | 2014 | -30.83 | Moderate Drought |

## SOCIAL SCIENCE

**Table10: Descriptive Statistics of rainfall (mm) over different span in Coochbehar**

| Year | N | Mean | Variance | Skewness | | Kurtosis | |
|---|---|---|---|---|---|---|---|
| | Statistic | Statistic | Statistic | Statistic | Std. Error | Statistic | Std. Error |
| 1971-1985 | 15 | 3318.4111 | 521455.979 | .208 | .580 | -.990 | 1.121 |
| 1986-2000 | 15 | 3522.4800 | 577035.272 | .159 | .580 | -.951 | 1.121 |
| 2001-2015 | 15 | 2919.4667 | 407208.350 | -.396 | .580 | .186 | 1.121 |
| 1971-2015 | 45 | 3253.4526 | 543225.540 | .149 | .354 | -.393 | .695 |

**Table 11: Model Comparison of Total Rainfall(mm) in Coochbehar District UnderTerai Zone of West Bengal**

| Model | RMSE | MAPE | MAE | BIC |
|---|---|---|---|---|
| ARIMA(1,0,1) | 634.41 | 16.62 | 493.42 | 13.24 |
| ARIMA(1,0,0) | 693.64 | 18.41 | 551.63 | 13.34 |
| **ARIMA(1,0,2)** | **608.59** | **16.23** | **482.39** | **13.24** |
| ARIMA(2,0,1) | 616.08 | 16.05 | 476.63 | 13.27 |
| ARIMA(2,1,1) | 615.35 | 16.24 | 481.43 | 13.35 |
| ARIMA(1,1,1) | 731.15 | 19.50 | 584.27 | 13.53 |
| ARIMA(1,2,1) | 937.51 | 24.78 | 774.72 | 14.04 |
| ARIMA(0,0,1) | 613.65 | 16.99 | 505.72 | 13.09 |

**Table 12: Rainfall Forecast in Coochbehar, ARIMA (1,0,2)**

| **Year** | 2018 | 2019 | 2020 |
|---|---|---|---|
| **Forecast Value (mm)** | 2941.51 | 2961.24 | 2916.69 |

**Findings:**

- ✓ The best fitted model shows that oil seed production and cultivated area for the year 2024-25 in Coochbehar district would be about 12.4 thousand tonnes (42.5% increase over 2014-15) and 20.1 thousand hectares (28.8% increase over 2014-15) respectively.
- ✓ Five moderate (1978, 1979, 2006, 2013 and 2014) and one severe drought years (2010) are noticed.
- ✓ Model shows that yearly rainfall for theyear2018, 2019 and 2020 would be 2941.51mm, 2961.24mm and 2916.69 respectively.

## SOCIAL SCIENCE

**Title of the Programme:** ***Modelling area, production and productivity of rice at Cooch Behar district***

**Project code:** RRSTZ/Rabi/17-18/10

**Associate Scientist/s:** Prof. S. Basak

**Objectives:**

- ✓ To study the data for probable presence of any cyclical trend
- ✓ To model the time series data through ARIMA and Non-linear modelling for forecasting purpose

**Materials:**

- ✓ For the present study secondary data has been collected from "Economic Review" published by "Department of Statistics & Programme implementation", Govt. of West Bengal and "Statistical Abstract" published by "Bureau of Applied Economics & Statistics", Govt. of West Bengal.
- ✓ Periods of data used are 1980-81, 1990-91 to 2013-14. The following table presents the required data for present study.

**Table 1: Year wise Area, Production & Productivity of Rice at Coochbehar District**

| Year | Area ('000 hec) | Production ('000 tonnes) | Productivity (kg./hec) |
|---|---|---|---|
| 1980-81 | 272.7 | 277.7 | 1018 |
| 1990-91 | 305.7 | 401.9 | 1315 |
| 1991-92 | 314.4 | 398.2 | 1266 |
| 1992-93 | 315.4 | 405 | 1284 |
| 1993-94 | 305.1 | 421.2 | 1381 |
| 1994-95 | 274 | 340.5 | 1242 |
| 1995-96 | 301.3 | 383.4 | 1272 |
| 1996-97 | 293.8 | 400.7 | 1364 |
| 1997-98 | 273.7 | 369.1 | 1349 |
| 2000-01 | 291.9 | 517.3 | 1772 |
| 2001-02 | 279.2 | 466.7 | 1672 |
| 2002-03 | 273.1 | 457.6 | 1676 |
| 2003-04 | 276.3 | 515.4 | 1866 |
| 2004-05 | 269.3 | 473.1 | 1757 |
| 2005-06 | 280.5 | 545.5 | 1945 |
| 2006-07 | 239.4 | 445.8 | 1862 |
| 2007-08 | 293.5 | 518.8 | 1768 |
| 2008-09 | 309.8 | 500.4 | 1615 |
| 2009-10 | 274 | 561 | 2047 |
| 2010-11 | 275.3 | 656.9 | 2386 |
| 2011-12 | 273.275 | 600.688 | 2198 |
| 2012-13 | 277.813 | 670.26 | 2413 |
| 2013-14 | 273.134 | 727.974 | 3998 |

# SOCIAL SCIENCE

## Methodology:

*ARIMA Modelling*

- ✓ The annual data on rice cultivated area, production and productivity of Cooch Behar district for the period from 1980-81, 1990-91 to 2013-14 were used for forecasting the future values using Auto Regressive Integrated Moving Average (ARIMA) models and nonlinear models.
- ✓ The ARIMA methodology is also called as Box-Jenkins methodology (Box and Jenkins 1976).
- ✓ The Box-Jenkins procedure is concerned with fitting a mixed ARIMA model to a given set of data.
- ✓ The main objective in fitting ARIMA model is to identify the stochastic process of the time series and predict the future values accurately.
- ✓ These methods have also been useful in many types of situations which involve the building of models for discrete time series and dynamic systems.
- ✓ Originally ARIMA models have been studied extensively by George Box and Gwilym Jenkins during 1968 and their names have frequently been used synonymously with general ARIMA process applied to time series analysis, forecasting and control.
- ✓ However the optimal forecast of future values of a time series are determined by the stochastic model for that series. A stochastic process is either stationary or non-stationary.
- ✓ The first thing to note is that most time series are non-stationary and the ARIMA models refer only to a stationary time series.
- ✓ Since the ARIMA models refer only to a stationary time series the first stage of BoxJenkins model is for reducing non-stationary series to a stationary series by taking first order differences.
- ✓ The main stages in setting up a BoxJenkins forecasting model are Identification, Estimating the parameters, Diagnostic checking & Forecasting.

## Results:

- ✓ In the present study the data for rice cultivated areas and production for the period 1950-51 to 2011-12 were used following the four stages of ARIMA model.
- ✓ At the Model identification stage, for forecasting rice area, production and productivity ARIMA model was estimated only after transforming the variable under forecasting into a stationary series.
- ✓ The stationary series is the one whose values vary over time only around a constant mean and constant variance.
- ✓ There are several ways to ascertain this.
- ✓ The most common method is to check stationarity through examining the graph or time plot of the data is non-stationary.
- ✓ Here it is found that all data reveals the property of non-stationarity as may be seen from the following plots of production data having mean value 451.81 and sd value 84.85.

## SOCIAL SCIENCE

- ✓ In this case, a visual inspection of the following autocorrelation function plot indicates that the SALES series is non-stationary, since the ACF decays very slowly.

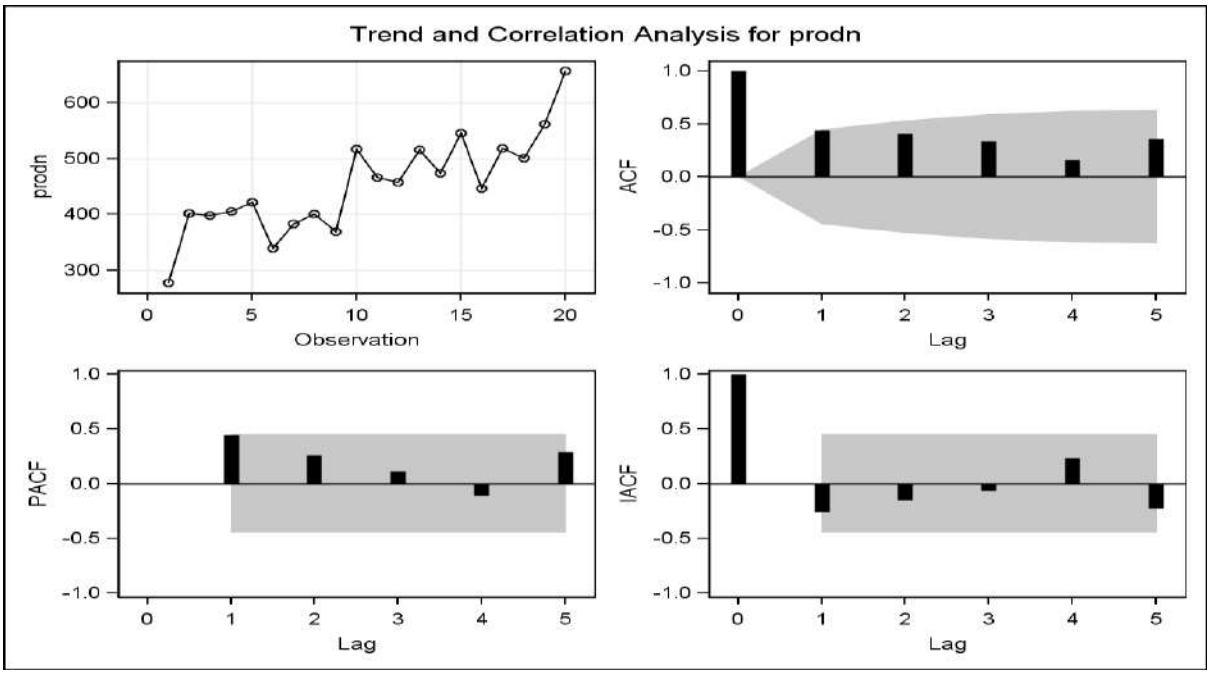



**Figure 1: Trend and correlation analysis for prodn**

- ✓ Non-stationarity in mean is corrected through appropriate differencing of the data. In this case difference of order 1 was sufficient to achieve stationarity in mean as obvious from the following plot of the 1st differenced data.

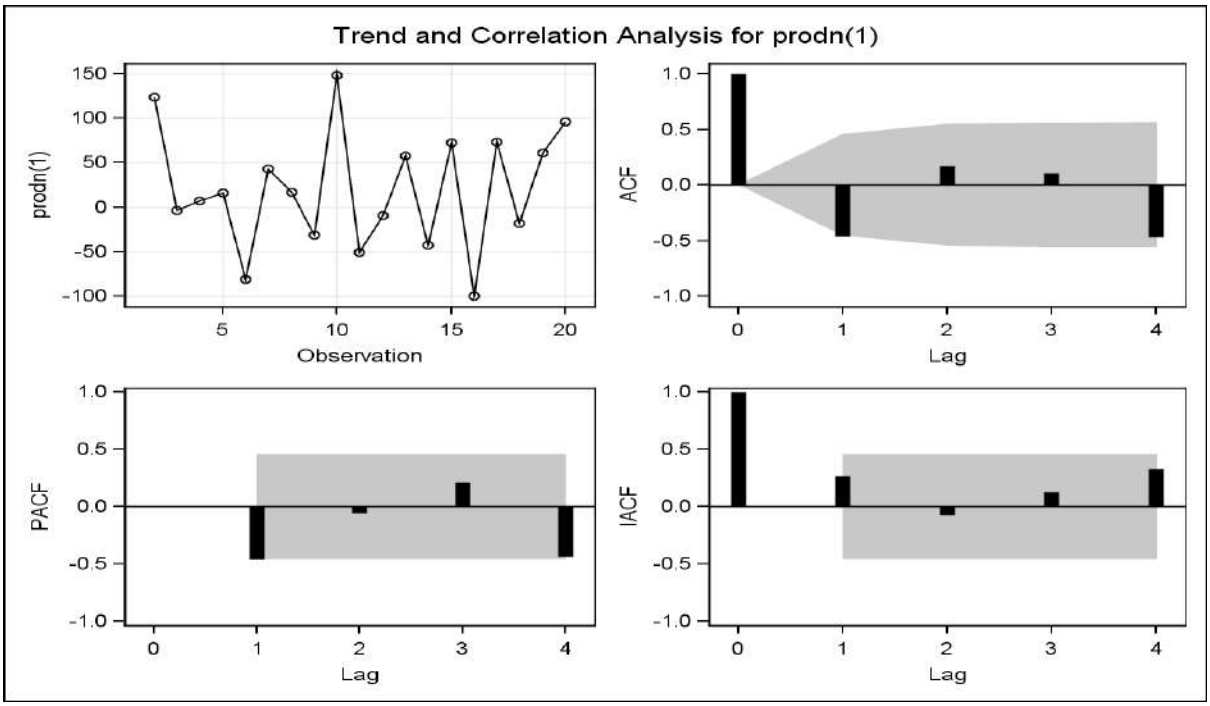



**Figure 2: Trend and correlation analysis for prodn(1)**

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- ✓ The newly constructed 1st differenced variable $w_t$ can now be examined for stationarity.
- ✓ The graph of $w_t$ was stationary in mean.
- ✓ The differenced series no longer has a noticeable trend.
- ✓ Instead it fluctuates around a fixed mean of 19.957.
- ✓ Differencing once appears to have introduced a stationary mean, so the non-stationarity in the original series was apparently of the homogeneous variety.
- ✓ The next step was to identify the values of p and q.
- ✓ The estimated auto correlation functions in the above plot dies out to zero quickly, suggesting that the mean of the first difference is stationary.
- ✓ The *acf* shows neither the decaying pattern suggestive of a pure AR or mixed ARMA model, nor the spike cut off pattern associated with the MA models.
- ✓ Therefore, the first differences appear to be a white noise series, suggesting the following ARIMA model for the differenced data i.e., $w_t = a_t$ or, $(1\text{-}B).\bar{z}_t = a_t$ where $z_t$ is the original data series, $a_t$ is the error term and $\bar{z}_t = z_t - \mu$. This is also true for the area and productivity data of rice.

*Non-linear Modelling*

- ✓ A good number of non-linear models are tested on the same set of data. For production and productivity data growth model is found to be the best fit with adjusted $R^2$ value -0.804 and 0.851 respectively.
- ✓ The following table also shows the coefficient values and their significance for the growth model:

**Table 2: Coefficients values**

| | Unstandardized Coefficients | | Standardized Coefficients | | |
|---|---|---|---|---|---|
| | B | Std. Error | Beta | t | Sig. |
| Year | .026 | .003 | .902 | 9.322 | .000 |
| (Constant) | 5.605 | .060 | | 93.632 | .000 |

The dependent variable is *ln*(Production).

- ✓ From the above table it is observed that both coefficients are highly significant and thus the fitted model is:- $Production = e^{5.605+0.026*year}$ .
- ✓ The following plot shows the best fit growth curve through the scatter of production data points.

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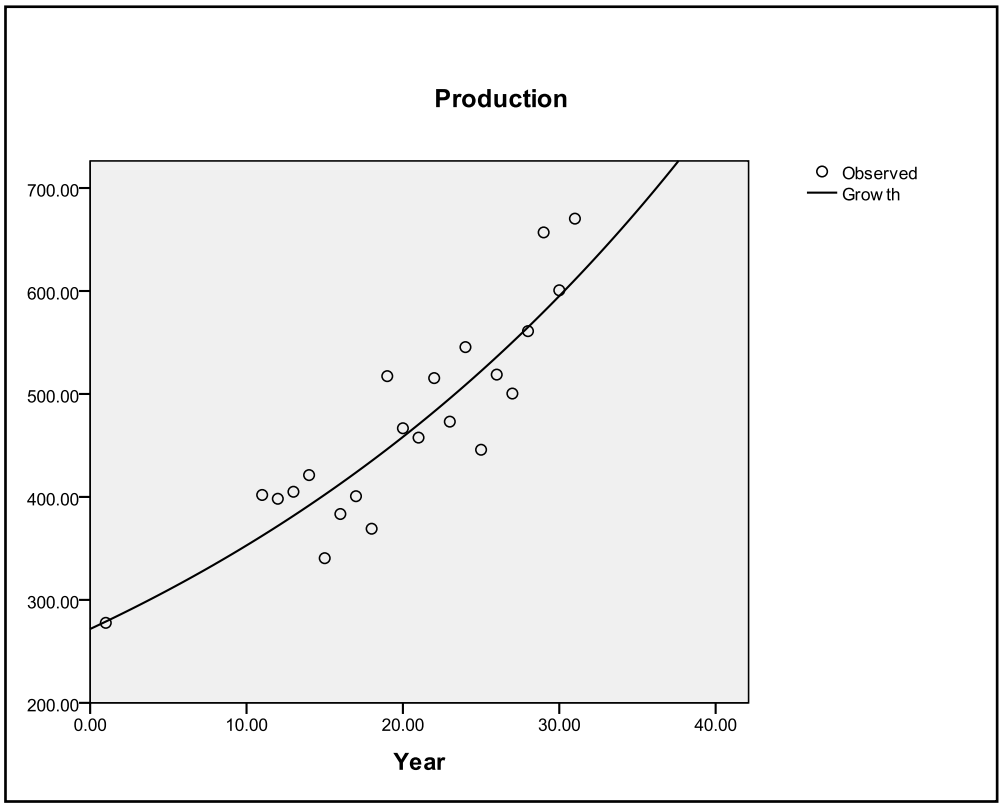


**Figure 3: growth curve through the scatter of production data points**

**Table 3: Coefficients of productivity data**

| | Unstandardized Coefficients | | Standardized Coefficients | | |
|---|---|---|---|---|---|
| | B | Std. Error | Beta | t | Sig. |
| Year | .029 | .003 | .926 | 10.977 | .000 |
| (Constant) | 6.800 | .057 | | 119.699 | .000 |

The dependent variable is *ln*(Productivity).

- ✓ From the above table it is observed that both coefficients are highly significant and thus the fitted model is:- $Productivity = e^{6.8+0.029*year}$ .
- ✓ The following plot shows the best fit growth curve through the scatter of productivity data points.

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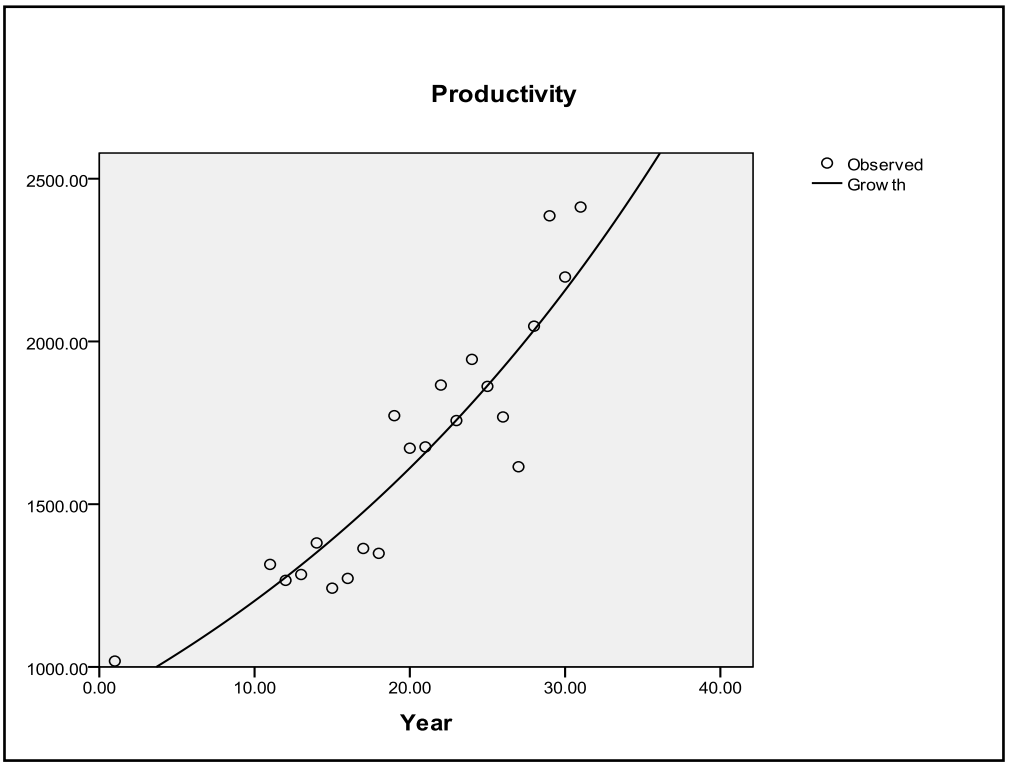


**Figure 4: Growth curve through the scatter of productivity data points**

- ✓ For both of production and productivity data the fitted model was validated using 2013-14 data and the forecasting error is found to be around 14%.
- ✓ For area data a $5^{th}$ order polynomial was found to give best fit with $R^2$ value 47% only.
- ✓ Hence a superior model may be again searched if more data are available.
- ✓ However, the area data was further subjected to time series analysis to find any trend and cyclical component in the data.
- ✓ An additive model is assumed as *area = trend + cyclical + error*.
- ✓ A small amount of decreasing linear trend was found.
- ✓ By eliminating this trend component and smoothing out (two period moving average) the error component the cyclical component is found as depicted in the following plot:

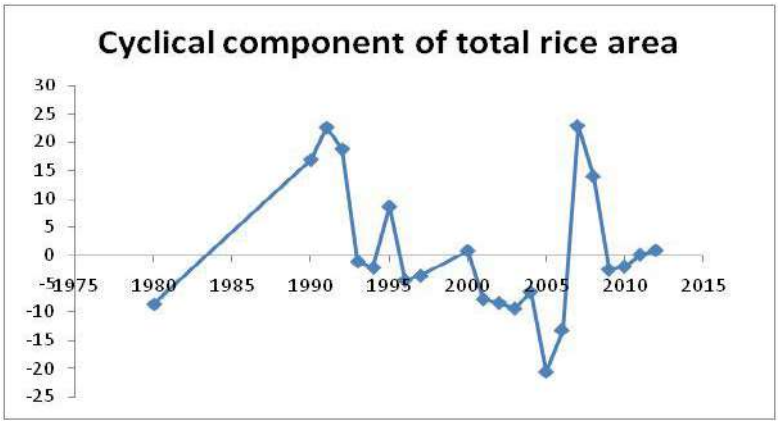


**Figure 5: Cyclical component of total rice area**

## SOCIAL SCIENCE

- ✓ From the above graph it is observed that total cultivated area of rice follows a cycle of 3-4 years with two major peaks in 1991-92 & 2007-08 and one major drop in 2005-06 followed by two minor drops in 1993-94 & 2009-10.

**Findings:**

- ✓ For the production, area and productivity data of rice the first differences appear to be a white noise series.
- ✓ The fitted models are:- $Production = e^{5.605+0.026*year}$

  $Productivity = e^{6.8+0.029*year}$
- ✓ Forecasting error is found to be around 14%.
- ✓ Area of rice cultivation follows a cycle of 3-4 years & it dropped steadily from 1991-92 to 2005-06.

**Future Scope:**

- ✓ For Area data a superior model may be searched using more past data as and when it will be available.
- ✓ Similar analysis will also carried out for several other cereal & pulse crops in due course of time.

**References:**


- Box GEP and Jenkin GM (1976). Time series of analysis. Forecasting and Control, Sam Franscico, Holden Day, California, USA.
- Prabakaran K and Sivapragasam C (2014). Forecasting areas and production of rice in India using ARIMA model. *International Journal of Farm Sciences* 4(1) :99-106.
- Rahulamin MD and Razzaque MA (2000). Autoregressive integrated moving average modeling for monthly potato prices in Bangladesh. Journal of Financial Management and Analysis 13(1): 74-80.


**Softwares used:**

- SAS version 9.2
- SPSS version 17.0

# Scientists Personal Information

## List of total staff under RRSTZ

| Sl. No. | Name | Designation | Area of Interest | Email |
|---|---|---|---|---|
| **Scientists** | | | | |
| 1 | Prof. P. Mukhopadhyay | Professor | Soil Science | drprabir1993@gmail.com |
| 2 | Prof. A. Choudhury | Professor | Soil Microbiology | ashokc540@gmail.com |
| 3 | Prof. (Mrs.) D. Sarkar | Professor | Fishery Science | dsarkar1509@gmail.com |
| 4 | Prof. S. Basak | Professor | Agril. Statistics | satyabasak@rediffmail.com |
| 5 | Prof. A. Ghosh | Professor | Agril. Statistics | arunava_ubkv@yahoo.co.in |
| 6 | Prof. S. Datta | Professor | Vegetable Science | suchanddatta@rediffmail.com |
| 7 | Dr. P. Poddar | Associate Professor | Agronomy | parthendu.poddar@rediffmail.com |
| 8 | Dr. S. Pal | Associate Professor | Agril. Entomology | palsento@gmail.com |
| 9 | Dr. R. Sarkar | Associate Professor | Agril. Engineering | rupaks19@gmail.com |
| 10 | Dr. N. Choudhury | Assistant Professor | Agril. Entomology | nc_ubkv@rediffmail.com |
| 11 | Dr. P.S. Patra | Assistant Professor | Agronomy | parthaagro@gmail.com |
| 12 | Dr. S. Hembram | Assistant Professor | Plant Pathology | Jitsatya2008@gmail.com |
| 13 | Mrs. G. Kumari | Assistant Professor | Agril. Economics | gunja.003@gmail.com |
| 14 | Dr. R. Mandal | Assistant Professor | Genetics , Plant Breeding and Plant Biotechnology | rup.biotech@gmail.com |
| 15 | Dr. N. Shit | Assistant Professor | Animal Science | drnonigopal@gmail.com |
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| 20 | Mr. Amal Dutta | Laboratory Attendant | | |
| 21 | Mr. A. Hoque | Junior Laboratory Attendant | | anarulssac@gmail.com |

AWARDS

| **Name of the Scientist** | **Name of the Award/ Recognition** | **Conferring Society** | **Year** | **Status (National/ International)** |
|---|---|---|---|---|
| Dr. N. Shit | Young Scientist in Animal Science | Venus International Foundation (VIRA) | 2017 | National |
| | Young Faculty Award in Animal Science | Education Expo-New Delhi | 2018 | National |
| | Guest lecturer & External examiner (Thesis Viva-voce) | Viswa-Bharati, Shantiniketan | 2018 | National |
| Dr. P. Mondal | Best paper presentation (ORAL) | COBACAS | 2017 | National |
| Dr. R. Mandal | Young Scientist in Genetics and Plant Breeding | Venus International Foundation (VIRA) | 2017 | National |

## Memberships

| Name of the Scientist | Name of the Journal/Society | Type of Membership |
|---|---|---|
| Dr. N. Shit | Veterinary Council of India | Life member |
| | West Bengal Veterinary Council | Member of 5 years |
| | Indian Poultry Science Association, IPSA 243122 | Life member |
| | Society for Animal Physiologists in India | Life member |
| | World's Poultry Science Association, IB | Annual member |
| | WB Poultry Federation | Annual member |
| | Exploratory Animal & Medical Research | Editorial Board |
| | Amity Journal of Agribusiness | Editorial Board |
| Dr. P. Mondal | Cooch Behar Association for Cultivation of Agricultural Sciences (COBACAS), Pundibari | LIFE MEMBER |
| Dr. S. Pal | Editorial Board Member for 'Journal of Invertebrate Sciences' by Society for Science and Technology, Bangalore (since 2018) | Editorial Board Member |
| | Entomological Society of India (ESI), New Delhi (since 2008) | Life Fellow |
| | Society for Biocontrol Advancement (SBA), Bangalore (since 2011) | Life Member |
| | Association for Advancement of Pest Management in Horticultural Ecosystems (AAPMHE), Bangalore (since 2011) | Life Member |
| | Entomological Research Association (ERA), Udaipur (since 2003) | Life Member |
| | Cooch Behar Association for Cultivation of Agricultural Sciences (COBACAS), Pundibari (since 2014) | Life Member |
| Dr. S. Hembram | Association for Advancement in Plant Protection | Life Member |
| | Cooch Behar Association for Cultivation and Science | Life Member |
| | Indian Phyto-pathological Society | Life Member |
| Mrs. G. Kumari | Trends in Biosciences | Life Member |
| | Coochbehar Association for Cultivation of Agricultural Sciences | Life Member |
| | International Journal of Agricultural Sciences | Life Member |
| Dr. (Mrs.) N. Choudhuri | 1. Cooch Behar Association of cultivation of agricultural sciences | Life Member |
| | 2. The *Indian Science Congress* Association | Life Member |
| Prof. A. Ghosh | Crop and Weed Science Society | Life member |
| | Society for Application of Statistics in Agriculture and Allied Sciences | Founder Member |
| Prof. (Mrs) D. Sarkar | Journal of inland fisheries society | Life member |
| | COBACAS | Life member |
| Dr. S. Dutta | Horticulture Society of India | Life member |
| | Indian Spice Society | Life member |
| | Crops and Weed Science Society | Life member |
| | Applied and Natural Sciences Foundation | Life member |
| | Forum of Scientist, Engineer's and Technologist | Life member |
| | COBACAS | Life member |
| | Spice India | Annual Member since 1999 |

## Memberships

| | | |
|---|---|---|
| Dr. R. Mandal | Indian society of root crops | Life member |
| | Society for Advancement of Science and Rural Development | Life member |
| | Cooch Behar Association for Cultivation and Science | Life Member |
| | Lawarence Press – Journal of Agricultural Biotechnology | Editorial Board Member |
| | Agriculture and Environmental Science Academy | Editorial Board Member |
| Dr. R. Sarkar | International Association of Hydrological Sciences | Member |
| | Indian Association of Hydrologists | Life Member |
| | American Society of Civil Engineers | S.M.ASCE |
| Dr. P. Poddar | Indian Society of Agronomy | Life Member |
| | Crop and Weed Science Society | Life Member |

## Project other than RRSTZ

| | Title of the Project | Role of the Scientist | Funding Agency | Sanction Budget | Sanction Year | Duration |
|---|---|---|---|---|---|---|
| Dr. N. Shit | Scientific evaluation and cost–benefit analysis of duck rearing system special emphasis to socio-economic up-liftment through women empowerment | PI | NABARD | 4.45 lakh | Sept. 2017 | 2 years |
| | Socio-economic development of weaker sections through piggery | Co-PI | RKVY | 31.90 lakh | 2016 | 03 years |
| | Image based identification of small animals i.e. pig & goat | Co-PI | ITRA, GOI | 17.06 lakh | 2017 | 02 years |
| | Production of safe broiler meat with no fear of hazardous antibiotic residue | Co-PI | RKVY | 34.96 lakh | 2017 | 03years |
| Dr. P. Mondal | Residue analysis of Buprofezin 20%+ Acetamiprid 2% WP on rice | P.I. | Krishi Rasayan Exports Pvt. Ltd. | 7.48 Lakhs | 2016 | 2 Years (2016-2018) |
| Dr. S. Pal | Survey of Pests and Diseases of Medicinal Plants in West Bengal | PI | NMPB, Ministry of AYUSH | 34.01 lakh | Since December, 2017 | 3 Years |
| Dr. S. Hembram | Survey and surveillance for wheat blast caused by Magnaportheoryzaepathotype*Triticum*and strategic research to manage it. | Centre Co-PI | MFSM, Ministry of Agriculture, Govt. of India | 24.788 | 2017-18 | 3 Years |
| | Survey of pest and diseases of medicinal plants in West Bengal. | Co-PI | National Medicinal Plant Board (NMPB), Ministry of AYUSH, Govt. of INDIA | 34.01 | 2017-18 | 3 Years |
| | Exploration of the Soil microbial diversity of different agro-ecological zones of North Bengal for Agricultural use. | PI | Institutional project (UBKV) | 12.00 | 2016-2017 | 3 Years |

**Project other than RRSTZ**

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| | Evaluation of bio-efficacy, phyto-toxicity and residue of Cyazafamid 34.5% SC on potato and tomato crops. | PI | KrishiRasayan Export Pvt. Ltd, New Delhi | 2.4 | 2017-18 | 2 Years |
| | Project on Development of a PCR based virus detection system for Solanaceousvegetatbles in North Bengal | Co-PI | Institutional project (UBKV) | 6.0 | 2016-17 | 3 Years |
| | Project on Collection, charecterization, in situ and ex-situ conservation of rice of North-Eastern India including the areas under jurisdiction of the University | | Institutional project (UBKV) | 17.5 | 2016-17 | 3 Years |
| | Evaluation of Bravo Top 550 SC (Chlorothalonil 40% + Defenconazole 4% SC w/w) against tomato and Chilli diseases. | Co-PI | Syngenta Pvt. Ltd. | 1.4 | | 2 Years |
| | To evaluate the bio-efficacy and Phyto-toxicity and residue analysis of Tricyclazole 75% WP on Paddy. | Co-PI | M/S Agrolife Science Corporation | 0.975 | 2017-18 | 1 year |
| | Evaluation of new fungicides offering better chemical management of Plant diseases | Co-PI | Syngenta India Limited, Kolkata | 14.40 | 2017-18 | 2years |
| Dr. N. Choudhuri | Bio efficacy, phytotoxicity and effect on natural enemies of some new generation insecticide molecule on different crops | Co-PI | Willowood Chemicals PVt. Ltd. | 8.55Lakh | 2017 | 2years |
| Prof. A. Ghosh | Sustainable Resilient Farming System Intensification in Eastern IGP | Socio Economic Study, data analysis and APSIM modell | DFAT-ACIAR | AUS $ 4,36,732.00 | 2014 | Cont. |

**Project other than RRSTZ**

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| | | ing | | | | |
| | Enhancing Pulses Production for Food and Nutritional Security, Improved Livelihood and Sustainable Agriculture in West Bengal | Socio Economic Study and data analysis | Department of Agriculture, Govt. of West Bengal | Rs. 19,69, 40000.00 including overhead charge | 2018 | 3 years |
| Prof. (Mrs) D. Sarkar | Establishment of rural bio -resources of North Bengal | Co-PI | Department of Biotechnology, New Delhi | 96 lakh | 2017 | Three years |
| Dr. S. Dutta | Mission for Integrated Development of Horticulture | PI and In-Charge | Directorate of Arecanut and Spice development, GOI, Calicut-673005 | 66.31433 alkh for the year 2017-18 | 2002-03 | Ongoing |
| Dr. R. Sarkar | Improving water use for dry season agriculture by marginal and tenant farmers in the Eastern Gangetic Plains | PI | Australian Centre for International Agricultural Research (ACIAR) | 81057 AUD | 2014 | 4 years |
| Dr. P. Poddar | 'Study on Bio-efficacy, phytotoxicity and residue analysis of some herbicides and chemical in tea and non-cropped area'<br>'Study on Bio-efficacy, phytotoxicity and residue analysis of some herbicides and chemical in tea' | PI | Willowood Chemicals Pvt. Ltd. | 11.63 lakh | 2017 | 02 years |
| | 'Promotion of oilseed crops in Northern districts of West Bengal for livelihood security of small and marginal farmers' | PI | Coramandel Agrico Pvt. Ltd. | 2.00 lakh | 2018 | 02 years |
| | Optimising nutrient use efficiency under zero | PI | Govt. of India | 13.635 lakh | 2017-18 | 01 year |

**Project other than RRSTZ**

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| | tillage operations in rice-maize cropping system in Coochbehar and Malda district of West Bengal | | | | | |
| | Optimising nutrient use efficiency under zero tillage operations in rice-maize cropping system in Coochbehar and Malda district of West Bengal, | Co-PI | International Plant Nutrition Institute | 2.87 lakh | 2017-18 | 01 year |
| Dr. H. A. Mondal | Dissecting the 'interactome' developed at sieve element due to aphid infestation for better understanding of enhanced insecticidal effect in resistant host plant | PI | SERB, DST, Govt. of India | 22.275 lakh | 2016 | 3 year |
| | Quality Parameter Testing of the Acclimatized *Valerianajatamansi* in Terai Zone, W.B and Mass Propagation of *Valerianajatamansi*, *Bergeniaciliata*, and *Piperlongum* for Distribution with Awareness Program | PI | Ministry of Ayurveda, Govt. of India | 23.375 lakhs | 2016 | 3 year |
| | Production of quality planting materials of some important medicinal plants through Identification, multiplication, supply of health elite genotypes and capacity building programme for improving rural livelihood in Northern part of West Bengal. | Co-PI | Ministry of Ayurveda, Govt. of India | 40.34 lakhs | 2017 | 3 year |
| | Collection, Conservation, Digitization and Standardization of | Co-PI | Ministry of Ayurveda, Govt. of India | 32.289 Lakhs | 2017 | 3 year |

**Project other than RRSTZ**

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| | protocol for Mass Regeneration of Selected Endangered, rate and Vulnerable medicinal plants of North East Region | | | | | |

**Publication from Other than RRSTZ Programme** (1st April, 2017 to 31st March, 2018)

| **Authors** | **Year of publication** | **Title of the paper** | **Journal Name, Volume and Page No.** | **NAAS/Scopus Index/Impact Factor** | **Publication Sources (Project Title/Thesis Title etc.)** |
|---|---|---|---|---|---|
| **N. Shit**, K.V.H. Sastry, G. Singh, R. Mandal and J. Mohan., | 2017 | Studies on metabolic hormones, sex steroids and mRNA expression of caspase 2, Bcl-XL gene in ovarian follicles of Japanese quail hens during stress. | Indian Journal of Poultry Science, Vol. 52, Issue -1 Page No 70-75. | - | Thesis |
| **N. Shit**, D.K. Hajra and S Baidya. | 2017 | Seasonal occurrence of gastrointestinal helminth parasites in cattle and buffaloes in Bankura district, West Bengal, India. | Exploratory Animal and Medical Research, 7(1): 58-63. | 4.27 | Extension service |
| G. Patra, S. Majhi, **N. Shit** and S. Biswas.. | 2017 | Effect of soya protein (soy crumbles) on the microbiological and sensory attributes of chicken meat powder. | Journal of meat science and technology, Vol. 5, Issue 1 Page No 9-15. | - | Thesis |
| **Mondal P,** Kumar R and Gogoi R | 2017 | Azomethine based nano-chemicals: Development, in vitro and in vivo fungicidal evaluation against Sclerotium rolfsii, Rhizoctoniabataticola and Rhizoctoniasolani. | Bioorganic Chemistry, 70: 153-162. | 9.23 | Preparation of Azomethine Based Nano-Biocides and Their Evaluation against Phyto-Pathogenic Fungi and Nitrifying Bacteria |
| **Pal, S**. and Gupta, A. | 2017 | Severe outbreak of rice green semilooper, Narangaaenescens (Moore) (Lepidoptera: Noctuidae) along with its parasitoid complex in sub-Himalayan West Bengal, India. | Entomological News, 127(3): 286-291. DOI: 10.3157/021.127.0301 | 6.23 | 'Evaluation of Vibrance Maxx Rice 450FS against diseases and pests of rice' Private Project Sponsored by Syngenta India Limited |

**Publication from Other than RRSTZ Programme** (1st April, 2017 to 31st March, 2018)

| | | | | | |
|---|---|---|---|---|---|
| Satpathi, S. K., **Pal, S**., Gurung, B., Datta, S., Kundu, A., **Mandal, R**., Laskar, N. and Kheroar, S | 2017 | Effect of physical characteristics and phenolic contents on jassid and pod borer of cowpea. | University of Sindh Journal of Animal Sciences, 1(1): 8-13. | - | M.Sc. Thesis of Sumit Kumar Satpathi (A-2014-22-M) entitled "Investigation on insect pests of Cowpea (Vigna unguiculata (L.) Walp.)" submitted during 2016 |
| Pal S., **Mandal R**., Sarkar S., et al., | 2017 | Species diversity and community structure of arthropod pests and predators in flax from darjeeling (india). | Brazilian archives of biology and biotechnology. 60 | 6.64 | Personal effort |
| S. Nandi, **S. Hembaram,** A. Adhikari, BK Tiwari and S. Dutta | 2017 | Host Infection beyond the Traditional Range of *Sclerotium* (Athelia) *rolfsii* with *Physalis minima* | Bioinformation 13(10): 333-338 | GS IF 0.80 | Personal effort |
| Deb, D., singh, J.P., Deb, S., Dutta, D., **Ghosh, A.,** and Chaurasia, R.S. | 2017 | An alternative approach for estimating above ground biomass using Resourcesat-2 satellite data and artificial neural network in Bundelkhand region of India. | Environmental Monitoring and Assessment https://doi.org/10.1007/s10661-017-6307-6 | 7.69 | Thesis Title of Dibyendu Deb:Modelling of biomass of some dominant forest species and estimation of carbon storage in a semi-arid region of India |
| **Ghosh, A**., Dey, K., Bhowmik, N., Ghosh, S.K., Bandyopadhyay, S., Medda, P.S. and Ghosh, A. | 2017 | Lemon cv. Assam lemon (*Citrus limon*Burm.) quality and soil-leaf nutrient availability affected by different pruning intensities and nutrient management. *Current Science*, 112(10), 2051-2065. | Current Science | 6.84 | Thesis of student from F/Hort. |

**Publication from Other than RRSTZ Programme** (1st April, 2017 to 31st March, 2018)

| | | | | | |
|---|---|---|---|---|---|
| Dey A, **Sarkar D**, Singh M and Barat S. | 2017 | DNA barcoding of four ornamental fishes of Genus *Botia*from Eastern Himalaya. | International Journal of Science and Research 6(6) : 608-611 | IF 6.39 | Breeding behaviour, embryonic development and barcoding of the ornamental loaches of terai region of West Bengal. |
| **Datta, S**., Chakraborty, S., Jana, J. C., Debnath, A., Roy M. K. and Haque S. | 2017 | Effect of Different Micronutrients on Turmeric Variety Suranjana in Terai Region of West Bengal, | *Journal of Applied and Natural Science*, 9 (3): 1696 -1702. | 4.84 | AICRP on Spices |
| **Datta, S**., Jana, J. C., Bhaisare, P. T. and Nimbalkar, K. H. | 2017 | Effect of organic source of nutrients and biofertilizers on growth, yield and quality of turmeric (*Curcuma longa* L.) | *Journal of Applied and Natural Science* 9 (4): 1981 – 1986. | 4.84 | MIDH Scheme |
| Chakraborty, S,. **Datta S**., Debnath A.and.Roy M K. ( | 2018 | Evaluation of some important ginger genotypes in terai region of West Bengal. | *International Journal of Science, Environment and Technology*, *7* (2) : 715-722. | 3.98 | AICRP on Spices |
| Thapa, A., **S. Datta**, A.N. Dey and Baisare, P. | 2017 | Advance Propagation Techniques in Important Spice Crops. | *International Journal of Current Microbiology . Applied Sciences* 6(9): 1979-1985. | 5.38 | Review paper |
| Chattopadhyay N., **Mandal R** and Tarafdar J., | 2017 | an evolutionary analysis of rice tungro bacilliform virus collected from odisha, india | Journal of mycologypathology research. 55(3) 243-249 | 4.90 | Thesis |
| Roy SK., Chakraborty M., Hijam L., Mandal H.A., **Mandal., Mandal R**., Kale Va., Ashokappa Nv., Sur B. And Dash Sk. | 2017 | Variability comparison of mustard crosses in advanced segregating generations . | International journal of pure applied biosciences: 5(6): 948-956 | 4.74 | Oil seed Project, Dept. of GPB |
| Chattopadhyay N., **Mandal R** | 2017 | probable location identification of inserted | Annunls of plant | 4.82 | Thesis |

**Publication from Other than RRSTZ Programme** (1st April, 2017 to 31st March, 2018)

| | | | | | |
|---|---|---|---|---|---|
| and Tarafdar J., | | tungro resistant gene in rice cultivar. | protection science: 25(2): 324-329 | | |
| Roy S., Hijam L., Chakraborty M., Ashokappa N V., Rout S., Kale VA., Sur B., Maying B., Das A., Kundu A., **Mandal R.,** Mandal Ha. | 2018 | Cause and effect relationship in yield and its attributing traits in early segregating generations of mustard crosses under terai agro-climatic zones of West Bengal, India. | International journal of current microbiology and applied science. 7 (3): 1-5 | 5.38 | Oil seed Project, Dept. of GPB |
| Reddy BJ., **Mandal R**., Chakroborty M., Hijam L and Dutta P., | 2018 | a review on potato and its genetic diversity | International journal of genetics: 10(2): 360-364. | 4.46 | Review Paper |
| Gharde, S. K. and **Chaudhuri, N.** | 2017 | Effect of Host Plants on the Growth and Development of the Polyphagous Defoliator *Cricula Trifenestrata* Helfer (Lepidoptera: Saturniidae) | International Journal of Bio-resource and Stress Management. 8(4):521-528 | 4.65 | Life system study of *Cricula trifenestrata* Helfer (Saturniidae: Lepidoptera) towards formulation of its management strategy |
| **Chaudhuri, N**., Banerjee, D., Ghosh, A. and Senapati, S.K. | 2017. | Identification of prediction model on population buildup of *Dactynotus carthemi* HRL on safflower (*Carthamus tinctorius* L.) for timely intervention | Journal of Entomology and Zoology Studies. 5(4): 1775-1779. | 5.53 | Safflower aphid (*Dactynotus carthemi* HRL) and its management |
| S.K. Gharde and **N. Chaudhuri** | 2018 | The life history and population growth parameters of leaf eating caterpillar *Cricula trifenestrata* helfer (Lepidoptera: Saturniidae) infesting *Machilus bombycina* king | International Journal of Current Microbiology and Applied Sciences 7(2): 710-717 | 5.38 | |
| Patra A., Sinha AK., Rakesh S., Biswas S. and **Mukhopadhyay P.** | 2018 | Different fractions of boron in soils of alfisol and entisol of West Bengal | Journal of pharmacognosy and phytochemistry 7(1): 510-513 | 5.21 | Thesis |
| Sarkar D., Rakesh S., Sinha | 2017 | Forms of phosphorus in some acidic | International journal of | 4.77 | Thesis |

**Publication from Other than RRSTZ Programme** (1st April, 2017 to 31st March, 2018)

| | | | | | |
|---|---|---|---|---|---|
| AK. and **Mukhopadhyay P.** | | entisols of subtropical eastern India | plant & soil science 19(3): 1-9 | | |
| K. Ravi Kumar, **Rupak Sarkar**, C.P. Suresh, M.R. Bhanusree, S.K. Ghosh, M. Sattiraju and S. Chakravarty. | 2017 | Growth, Yield and Water Use Efficiency as Influenced by Irrigation Scheduling in Banana (Musa spp., AAA group) var. Grand Naine During Water Deficit Period in Terai Zone of West Bengal | International Journal of tropical Agriculture, 35(2), 245-258 | 3.49 | Ph.D. Thesis |
| Shovik Deb, Manoj K. Debnath, Somsubhra Chakraborty, David C. Weindorf, Deo Kumar, Dibyendu Deb and **Ashok Choudhury** | 2018 | Anthropogenic impacts on forest land use and land cover change: Modelling future possibilities in the Himalayan Terai. | *Anthropocene.***21**: 32-41. | Unknown | Project |
| Partha Sarathi Patra, Shyamal Kheroar, **Ashok Choudhury**, and Rajesh Saha, | 2017 | Responses of split application of nitrogen on the performance of *Kharif* rice (*Oryza sativa* L.) in Terai zone of West Bengal. | *Asian J. Soil Sci.*, **12** (2): 265-270: | 4.34 | Thesis |
| Partha Sarathi Patra, Md Aziz, Rajesh Saha and **A. Choudhury** | 2017 | Bio-efficacy of Bispyribac acid 40% SC against weed flora in Rice (*Oryza Sativa*L). | *International journal of tropical Agriculture*. **35(2)**: 259-265. | 3.49 | Thesis |
| Bisweswar Mahato, Somsubhra Chakraborty, D.P. Ray, Parimal Panda, Bappa Paramanik, Naba Kishor Mahato, Arindam Kundu, Anarul Hoque and **Ashok Choudhury** | 2017 | Evaluation of chemical and biological indices for carbon and nitrogen mineralization of various organic matters used in tea garden. | *International Journal of Bioresource Science*. **4 (1)**: 47-56. | 3.54 | Thesis |
| Parimal Panda, Bisweswar Mahato, Somsubhra Chakraborty, Bappa Paramanik, Ranajit Panda, Naba Kishor Mahato, Arindam Kundu, Abhijit Mahato and **Ashok Choudhury** | 2017 | Organic Phosphorus Mineralization by Isolated Phosphorus Solubilizing Fungi. | *Journal of Agriculture and Technology* | | Thesis |
| Puspendu Bikash Bag**,** Parimal | 2017 | Atmospheric nitrogen fixing capacity of | *International Journal of* | 5.38 | Thesis |

**Publication from Other than RRSTZ Programme** (1st April, 2017 to 31st March, 2018)

| | | | | | |
|---|---|---|---|---|---|
| Panda, Bappa Paramanik, Bisweswar Mahato and **Ashok Choudhury**. | | Azotobacter isolate from Cooch Behar and Jalpaiguri Districts soil of West Bengal. | *Current Microbiology and Applied Sciences*.**6 (3)**: 1775-1788. | | |
| Valeria Cardelli, David C.Weindorf,Somsubhra Chakraborty, Bin Li, Mauro De Feudis, Stefania Cocco, Alberto Agnelli, **Ashok Choudhury**, Deb Prasad Ray, Giuseppe Corti | 2017 | Non-saturated soil organic horizon characterization via advanced proximal sensors. | *Geoderma*, **288**: 130-142. | 10.04/IF 4.063 | Thesis |
| Panda Parimal, **Choudhury Ashok**, Chakraborty Somsubhra, Ray DebPrasad, Deb Shovik, Patra Partha Sarathi, Mahato Bisweswar, Paramanik Bappa, Singh Anil Kumar, Chauhan Rajesh Kumar. | 2017 | Phosphorus Solubilizing Bacteria from Tea Soils and their Phosphate Solubilizing Abilities. | *International Journal of Bioresource Science*. **4 (2)**: 113-125. | 3.54 | Thesis |
| Somsubhra Chakraborty, David C. Weindorf,Shovik Deb, Bin Li, Sathi Paul, **Ashok Choudhury**, Deb Prasad Ray. | 2017 | Rapid assessment of regional soil arsenic pollution risk via diffuse reflectance spectroscopy. | *Geoderma*, **289**: 72–81. | 10.04/IF 4.063 | Thesis |
| Sunil Kumar, Bholanath Saha, Sushanta Saha, Anupam Das, Parthendu Poddar and Manikant Prabhakar | 2017 | Integrated nutrient management for enhanced yield, nutrients uptake and their use efficiency in Rice under intensive Rice-Wheat cropping system' | *International Journal of Current Microbiology and applied Sciences',* Volume 6 Number 10 pp. 1958-1972 | 5.38 | |
| Editors: Vijay Singh Meena, Pankaj Kumar Mishra, Jaideep Kumar Bisht, Arunava Pattanayak | 2017 | Book chapter on Biological Nitrogen fixation for sustainable agriculture: *In: Agriculturally important microbes for sustainable agriculture.* | **Springer .**Volume 2: Applications in crop production and protection pp 83-128 | | |

**Publication from** RRSTZ **programme**

(1st April, 2017 to 31st March, 2018)

| **Authors, Year of publication, Title of the paper** | **Journal Name, Volume and Page No.** | **NAAS/Scopus Index/Impact Factor** | **Project Code and Title of the RRSTZ Programme** |
|---|---|---|---|
| **Mandal R., Pal S.** and **Shit N.** 2017. Unlocking Genetic Diversity in Selected Chickpea Genotypes using Morphological and Molecular Markers. | Current Agriculture Research Journal, Vol. 5 Issue 1 Page No 50-57. | 4.36 | Project |
| Satpathi, S.K., **Pal, S**., **Mandal, R., Shit, N.** and **Sarkar, A.** 2016. Ecofriendly biointensive pest management modules in cowpea under sub-Himalyan West Bengal, India. | The Journal of Plant Protection Sciences, 8(1-2): 1-6. DOI: 10.17582/journal.jpps/2016/8.1-2.1-6 | - | RRSTZ/KHARIF/16-17/02 entitled "Eco-friendly management of major insect pests in cowpea" |
| **Sarkar D** and Mukherjee A (2017).Domestication of *Macrobrachiumrosenbergii* in terai region of West Bengal. | International Journal of Fisheries and Aquatic Studies 5(5) : 01-06 | IF 5.62 NAAS 3.99 | RRSTZ/KHARIF/16-17/11(2) |

**Seminar/Symposium/ Conference/ Training**

| Name of the Scientist | Title of the Seminar/Symposium/ Conference/ Training | Organizing society | Duration & Year | Status (National/ International/ Regional) |
|---|---|---|---|---|
| Dr. N. Shit | 1st Farm Innovation Congress, 2018 and National Conference on Innovative Farming for Food and Livelihood security in Changing Climate. | Society for Advancement of Agricultural innovation, BCKV | 12-13th Jan. 2018 | National |
| | 2nd Regional Science & Technology Congress, Government of West Bengal. | Siliguri College, Darjeeling | 7-8 Dec. 2017 | Regional |
| Dr. P. Mondal | National Conferenceon Enhancing Nutritional Security throughClimate Smart Farming Practices | COBACAS | 17-18th March, 2018 | National |
| Dr. S. Pal | International Symposium on Biodiversity and Biobanking (BIODIVERSE 2018) | IIT, Guwahati | 27-29 Jan, 2018 | International |
| Gunja Kumari | Advanced Analytics In Developing Market Intelligence | ICAR-NAARM | 14th Nov. – 4th Dec., 2017 | National |
| Dr. R. Mandal | 1st Farm Innovation Congress, 2018 and National Conference on Innovative Farming for Food and Livelihood security in Changing Climate. | Society for Advancement of Agricultural innovation, BCKV | 12-13th Jan. 2018 | National |
| Dr. P. Poddar | *National symposium on Towards Climate Smart Agriculture-A Key To Livelihood Security*, | IAS, University of Calcutta, West Bengal. | 9—11th December, 2017, | National |