NATP-2

Generated Technology Factsheet under CRG Sub-projects

PIU-BARC

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BARC Component
Enhancing Agricultural Technology Generation

Generated Technology Factsheet
under CRG Sub-projects

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Preamble

National Agricultural Technology Program Project (NATP) is a comprehensive project with focus on revitalizing the agricultural technology system and increasing agricultural productivity in Bangladesh. The World Bank (WB), Internationl Fund for Agricultural Development (IFAD), The United States Agency for International Dedelopment (USAID) and the Government of Bangladesh (GoB) are funded to NATP-2. The long-term NATP development program is for a period of 15 years in three phases. The development objective of the phase II of the NATP is to strengthen the capacity of research of the national agricultural technology system in Bangladesh.

The Project Implementation Unit (PIU) of BARC is the prime national agricultural research component and is the implementing arm of all NATP activities on behalf of the Bangladesh Agricultural Research Council. In attaining the projects objectives concerning BARC/NARS, the PIU-BARC in close collaboration with the NARIs and related others is undertaking activities to transform agricultural research more participatory and demand-driven and develop technologies to promote sustainable intensification, diversification mechanization of agriculture through efficient natural resources management.

The first window of NATP-2 research investment is Competitive Reseearch Grants (CRGs) program that promotes basic, strategic, demand driven and adaptive research with better research extension- farmer linkages.

The 69 technologies has been generated from the Competitive Research Grants (CRGs). PIU-BARC has prepared technology fact sheet for better linkages make new technology more relevant and speed up dissemination to farmers.

I appreciate the efforts of my team and wish through collective efforts to reach the desired objectives of the NATP-2.

I appreciate the contribution and sincere efforts of all the researchers of NARS, universities. I acknowledge the hard work of the PIU-BARC personnel and the technical divisions of BARC to visualize the hard work through this report.

Director
PIU-BARC, NATP-2

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Crops Technologies

Bio-Organic Fertilizer: A Green Technology to Improve Soil Health and Rice Yield

Introduction

Modern agriculture highly relies on chemical fertilizer. Long-term use of chemical fertilizer impairs soil biology and causes environment pollution. Loss of soil health is directly related to crop production. Breaking rice yield ceiling needs healthy and productive soil. In this context, application of bio-organic fertilizer would be helpful to improve soil biology and rice yield.

Description of the Technology

- An environment friendly BRRI Bio- Organic Fertilizer is recommended for improvement of soil health and rice yield
- This bio-organic fertilizer is the combination of vegetables waste/ degradable kitchen waste (79%), rice husk biochar (15%) and rock phosphate (5%) along with a consortium of low cost isolated beneficial bacteria of 1 gm (dry wt.). Rock phosphate (5%) would be incorporated in this product as an alternate of TSP fertilizer for rice production
- Incorporated phosphate solubilizing bacteria would be able to ensure bio-available P from rock phosphate during crop growing period while carrier materials are bio-degradable kitchen waste/vegetable waste (79%) available in kacha bazar and chita-dhan biochar (15%)
- The beneficial bacteria added in this bio-organic fertilizer are indigenous and isolated from favorable and un favorable rice ecosystem (drought, saline and acid soil) and make it available to the plants
- Bio-organic fertilizer @ 1 ton ha^{-1} for Aus rice, 2 tha^{-1} for Boro and T. aman rice could be applied during final land preparation
- Application of BRRI Bio-organic fertilizer reduces 30% use of Urea and full dose (100%) of TSP fertilizer in rice culture
- This technology is applicable for all over Bangladesh including saline soil.

Benefit of the Technology

- Application of BRRI bio-organic fertilizer@ 1 t /ha in Aus, 2 t / ha in T. Aman and Boro season could reduce use of 25 - 30% urea and eliminates 100% TSP fertilizer requirement for rice production and could obtained higher grain yield (5 to 20%) as compared to full (100%) chemical NPK fertilizer
- Adds Carbon to the soil as 15% Bio-char incorporated
- Improves soil biology with beneficial soil bacteria and reduce the import cost of fertilizers
- It would also help to keep the environment clean and green.

Researcher:

Dr. Umme Aminun Naher
Principal Scientific Officer
Soil Science Division
Bangladesh Rice Research Institute
Mobile: 01913151914, E-mail: nahar39@gmail.com

Crop Productivity Enhancement in Beel Areas

Introduction

Beel (Low land goes under water and remains under water about 4-5 months generally from July to November) area are under unfavourable ecosystem covering an area of 2.43 million hectares in Bangladesh. Beel is less productive and remains fallow in most of the part of the year. Boro rice is the main crop in beel area which requires huge amount of water. There is a possibility of improving crop productivity through adaptation of HYV of crops in the cropping pattern along with their production technologies. Hence, alternate cropping rather than boro rice can save underground water resource and improve crop productivity. In this context, short duration mustard varieties before boro rice and broadcast aman rice after boro rice can improve the cropping pattern in Beel area. Ratooning aus rice and intercropping of Garlic + Watermelon are the two important ways to improving crop productivity in the beel areas. Moreover, higher yield could be achieved by adopting improved varieties of wheat, maize, mustard, garlic, lentil, onion etc.

Description of the Technology

- High yielding varieties of mustard (BARI Sarisha-14, BARI Sarisha-15), wheat (BARI Gom-30), maize (NK-40, 900 M Gold &Miracle), garlic (BARI Rashun-3) and onion (BARI Piaj-4) could be cultivated in the upper land of Chalan Beel area for producing higher yield
- Fertilizer dose @ 325-90-185-60-5-2.5 kg ha^{-1} + Weeding at 20 days after emergence (DAE) for maize, 140-44-70-30-1.8-1 kg ha^{-1} + Weeding at 15 DAE for mustard, 125-45-31-25-2 -1 kg ha^{-1} + Weeding at 20 days for wheat, 150-75-200-50-5.6 -2.5 kg ha^{-1} + Weeding at 30 days for onion of N-P-K-S-Zn-B are recommended for better yield
- Fertilizer dose of 125-190-206-25-5-2.5 kg ha^{-1} of N-P-K-S-Zn-B sources + Weeding at 30 days after dibbling is recommended for garlic + watermelon intercropping in Chalan Beel area
- Broadcast aman rice could be grown after boro rice in the beel area as a chance crop for improving the crop productivity
- Fertilizer dose @ 40-20-10-5-0.8-0.5 kg ha^{-1} + Weeding at 5-7 days after harvest of main rice for ratooning and @ 26-11-11-5-0.8-0.8 kg ha^{-1} + Hand weeding at 20 DAE and 50-60 DAE for B. aman rice of N-P-K-S-Zn-B may be profitable in beel area
- The sowing / dibbling time of crops depends on recession of water: 1-15 November (mustard), 15 November-5 December (maize, wheat, garlic), 15 December-20 January (onion) is suitable in Beel area. However, mustard, wheat, maize, onion, garlic, ratoon rice and B. aman rice could be harvested between 6-12 February, 27-30 March, 15-19 April, 25 March-8 May, 25-30 November and 7-13 December, respectively
- Intercultural operations other than weeding, irrigation (1 for mustard, 2 for wheat and 3 for maize, 2-3 for onion and garlic) and spraying of insecticides and fungicides need to be applied as and when required
- Would be suitable for the Beel areas of Bangladesh.

Benefit of the Technology

- Higher yield of BARI Sarisha -14 and 15 (1.60 - 1.75 t ha^{-1}), BARI Gom-30 (5.02 t ha^{-1}), maize (NK-40, 900 M Gold and Miracle- 10.02 – 10.64 t ha^{-1}), BARI Rashun-3 (12.54 t ha^{-1}), BARI Piaj-4 (19.61 t ha^{-1}), main rice or ratooning (2.10 t ha^{-1}) and B. aman rice (1.59 -1.61 t ha^{-1}) could be obtained
- Garlic equivalent yield of 25.22 t ha^{-1} may be obtained from garlic + watermelon intercropping in Chalan beel area
- Higher BCR of maize (1.88-2.24), mustard (1.59-1.65), wheat (1.78-1.81), garlic (1.64), onion (2.00), garlic+ watermelon intercropping (2.84) and B. aman for ratooning (3.82) could be obtained.

Researcher:

Dr. Md. Abul Khayer Mian
Principal Scientific Officer
Agronomy Division
Bangladesh Agricultural Research Institute
Joydebpur, Gazipur 1701, Cell-01914-661301, E-mail: mianmd.abulkhayer@yahoo.com

Tobacco Replacement in Char Land through High Value Crops

Introduction

Chars are newly developed lands in different river beds and basins that comprise the area of approximated 0.82 million ha in Bangladesh out of which about 64 to 97% area are cultivable. Cultivated soils of chars are mostly sandy loam to silty loam. Total charland area of Tangail district is about 19763 ha, of which 9662 ha under Bhuapur. In Tangail total 135 ha area goes under tobacco of which about 56 ha under Bhuapur. Most of the charlands remain fallow during rabi season. Due to lack of money and profitable offers from different tobacco companies, some farmers are inspired to cultivate tobacco which is very harmful for soil and human health. There is a great scope to replace tobacco by cultivating different high value and nutrient rich crops such as wheat, maize, groundnut, sweet potato, black cumin, vegetables etc with their newly released modern varieties. So, there is a high possibility of increasing crop productivity and income in charlands by replacement of tobacco through cultivation of modern varieties of different high value crops as well as adoption of improved management practices.

Description of the Technology

- Wheat (BARI Gom-30 & BARI Gom-33), maize (BARI Hybrid Maize-9), groundnut (BARI Chinabadam-8) black cumin (BARI Kalozira-1), sweet potato (BARI Misti Alu –12), chilli (Bindu), bottle gourd(Local) are recommended to cultivate in the charlands due to their higher yield and economic return
- Wheat, maize, groundnut, sweet potato, black cumin, chilli and bottle gourd could be sown/planted between 2nd week of November, 2nd to 3rd week of November, last week of October to 1st week of November, 2nd to 3rd week of November, last week of October to last week of November, 1st to 2nd week of October and 2nd to 3rd week of October and the said crops could be harvested between 10-14 March, 10-16 April, 10-23 April, 9-15 April, 10-13 April, 2nd week of March to 3rd week of May (Green chilli of) and 2nd week of April to 3rd week of May
- Wheat, maize, groundnut, black cumin, chilli and bottle gourd could be fitted in the existing cropping patterns which can replace tobacco
- Manures and fertilizers should be applied as per recommendation of Fertilizer Recommendation Guide, 2018
- Additional application of gypsum fertilizer @ 37 kg/ha after flowering stage of groundnut may be recommended for 56% higher yield than the traditional practices
- Intercultural operations as well as application of insecticides and fungicides need to be done as and when required
- Suitable areas would be the charlands of Bangladesh particularly Tangail.

Benefit of the Technology

- Higher yield of BARI Gom-30 & BARI Gom-33 (3.90 – 4.06 t/ha), BARI Hybrid Maize -9 (9-9.5 t/ha), BARI Chinabadam -8 (2.5 – 2.76 t/ha), BARI Misti Alu-12 (22.75 – 23.25 t/ha),BARI Kalozira-1 (0.98-1.2 t/ha), Bindu chilli (9-10.5t/ha) and bottle gourd (27-27.5 t/ha) could be obtained over the existing cultivars/genotypes under the charland of Bhuapur, Tangail.
- Higher BCR of wheat (1.84-1.87), maize (2.17), groundnut (2.92), sweet potato (3.75), black cumin (4.21), chilli (3.02) and bottle gourd (3.22) could be obtained over the existing genotypes/cultivars.
- High value and nutrient rich crops insured higher yield and much more (97 to 446 %) economic return than tobacco, which ultimately uplifted farmers livelihood and replace tobacco.

Researcher:

Mohammad Asiqur Rahaman
Senior Scientific Officer
On-Farm Research Division
Bangladesh Agricultural Research Institute (BARI)
Tangail-1900, Cell phone: 01717210374, E-mail: asiqurbari@gmail.com

Integrated Rodent Management of Rice and Wheat

Introduction

Rice and wheat are the major food crops in Bangladesh. Rat is a major vertebrate pest in the country's agriculture. It causes serious damage to crops both in the field and in storage. Rat causes considerable damage to rice (5%) and wheat (15%). The bandicoot rats (Bandicota spp.) are the major vertebrate pests (70%) of rice and wheat. Rat damage starts in booting stage of crop and the highest damage occurs at grain filling to ripening stage. Rat hoards (stores) a considerable amount of rice (3-5 kg) in their burrow. It causes about 6% loss in deep water rice which is estimated about 80,000 MT, 10% in wheat i.e. about 77,000 MT and about 1% in T. aman rice (88,000 MT). Rats are also a major problem in the poultry sector where about Tk. 18,000/- in cash loss per farm household per year. The integrated rodent management of rice and wheat can reduce their damage in considerable extent.

Description of the Technology

- Farmers generally use acute poison bait for controlling rat. Majority (80-90%) farmers use acute poison (Zinc phosphide: Zn3P2: 2%) in their crop field for rodent control. They place acute rodenticide on a piece of paper and put openly beside rat burrow openings and not interested to use traps in crop field due to risk of stealing. Chronic rodenticide (Bromadiolone: 0.05%) is costly compared to acute ones. The integrated rodent management technology consists of kill or live trap plus acute or chronic poison or combination of both acute and chronic poison with trap. First the trap would be set and then poison to be applied inside the burrow. All poisons under the technology are used in eco-friendly techniques i.e. poison wrapped with paper and inserted inside the burrow, then the burrow is sealed with soil. Sequential application of trapping with live or kill trap, acute and chronic poison baiting controls about 93% rodent in rice field. Success in rodent control depends mostly on proper setting of trap and placement of poison bait.

Benefit of the Technology

- The sequential application of trapping with live or kill trap and inside burrow baiting exceeds the rodent control of traditional practices by 40 to 50%; and acute poison baiting controls 70% rodent
- Only live trap controls about 35% rodent, while only kill trap controls 24% rodent
- Sequential application of trapping with live or kill trap, acute and chronic poison baiting controls up to 95% rodent in wheat field and 80% in rice field
- Setting only live trap and kill trap controls about 50% rodent

Researcher:

Dr. ATM Hasanuzzaman
Senior Scientific Officer, Vertebrate Pest Division,BARI, Gazipur.
Phone no. 02-49270062; Mobile: 01711149837
E-mail: hasanbari@yahoo.com; hasanbari01@gmail.com

Production and Bulb Preservation Techniques of Lilium

Introduction

Lilium is a lucrative and high demanded flower in international flower trade and commercially it is grown as cut flower for its long lasting (12-15 days) majestic flowering sticks with wide range of colour and attractiveness which has recently been introduced in Bangladesh due to its high demand and profitability. Even to meet up the local demand this flower is being imported from other countries specially China. Very few farmers are trying to cultivate this flower in a small scale with minimum germplasm collecting from neighboring countries. Bulb preservation is an important issue for the continuation of the lilium cultivation. The lilium bulbs are normally preserved in the cold storage (2-5^0 C temperature) for 6-8 weeks which is little bit difficult to maintain at farmers level. Under Bangladesh climatic condition 6-8 weeks are not sufficient to keep the bulbs at storage due to the difference between bulb harvesting and the next winter is too long. The farmers are trying to preserve lilium bulb in normal room condition for some time though it deteriorates the bulb quality. Preservation media is very much important to retain the moisture of the bulb. Moist coco dust is being used widely for lilium bulb preservation. Sawdust may be used as substitute of coco dust. Hence, development of production and bulb preservation techniques of lilium flowers are essential for its profitable production.

Description of the Technology

- Both Asiatic and Oriental lilium flowers could be successfully grown under Bangladesh climatic condition in the winter season (day temp. 20-25^{0}c and night temp. 14-16^{0}c)
- Shed house with the Ultra Violet (UV) poly film and Black Agro Shade net could be used for cultivation of lilium flowers
- Land should be prepared by adding coco-dust (soil and cocodust-50:50), cow dung 10 t ha^{-1} and need to be fertilized with Urea, TSP, MoP @ 300, 375 and 300 kg ha^{-1}, respectively. Cow dung, TSP and MoP could be applied as basal while Urea need to be applied in two equal splits at one month after planting and at spike initiation stage
- Lilium bulb should be planted from mid-November to end November maintaining spacing of 30 cm from row to row and 15 cm from plant to plant. Intercultural operations like irrigation, weeding, stacking, mulching as well as management of insect and diseases should be done as and when required. The spikes should be harvested when the lower most buds showed colour. After collecting flowers, plants with 3-4 leaves need to be kept in the field for bulb development. When the leaves become brown, bulbs should be lifted carefully and stored for next planting.
- Lilium bulbs could be preserved in cold storage (2.1-2.5^{0}c temperature and 85-90% relative humidity) with sawdust media but coco dust and the mixture of sawdust & coco dust (50:50) both may also be used as media for lilium bulb preservation to mitigate the availability of sawdust.
- Year round lilium flower could be grown under Greenhouse (temp.20-25^0 c).

Benefit of the Technology

- The flower growers as well as users both would be benefitted;
- Moreover, both flower and bulb import would also be reduced to some extent.

Researcher:

Dr. Farjana Nasrin Khan
Senior Scientific Officer
Floriculture Division, HRC
BARI, Gazipur-1701
Mobile: 01910-047191, E-mail: khan_farjana@yahoo.com

Improved Sugarcane Power Crusher for Goor Production

Introduction

Goor making is one of the important cottage industries in Bangladesh. About 53% of total produced sugarcane in the country is used for goor production and the used technology is still remains crude and old, which results in low production efficiency. At present juice extraction capacity of sugarcane crusher is about 40-45% of cane weight which is very low, where the prime mover is a 12 hp diesel engine having two pressing rollers with 14 inch (35 cm) diameter and one cutting roller with 5 inch(12.5 cm) diameter in vertical arrangement. On the other hand, due to some mechanical short falls, sometimes the crusher becomes jam. Therefore, development and dissemination of a suitable, efficient and modern crusher machine among the goor producers is utmost need. So, the improved sugarcane crusher has been developed to increase juice extraction rate and crushing capacity with less power consumption.

Description of the Technology

- The developed sugarcane crusher has 5 rollers and the diameter of each roller is 4 inches (10 cm). In this crusher sugarcane is crushed in three stages
- One chevron grooved roller is used to cut cane and make it easy for feeding to the crushing rollers. Another four rollers are used for pressing
- Two callers are fixed at both ends of the central roller and two pressing rollers moves between those callers. This system makes feeding laminar and protects machine from side jamming
- A 10.5 hp (Horse-power) diesel engine is the power source of this crusher which supplies power to gear box by belt-pulley system. There are four stages spur gear and pinion gear box, used for transmission of power to the rollers to attain the required 18 rpm.
- Sugarcane crushing rate is 300-370 kg/hr and juice extraction capacity is 55-68% of cane weight
- The suitable goor varieties of sugarcane are BSRI Akh 39, BSRI Akh 43, BSRI Akh 45, and ronanggon and the varieties BSRI Akh 41, BSRI Akh 42 and modhumala are chewing cane are crushed by this crusher. Juice extraction rate of goor variety is about 55-60% of cane weight and that for chewing variety is 62-68% of cane weight
- Suitable areas are the non mill zone area of Bangladesh (Nilphamari, kurigram, Lalmonirhat, Chapai Nawabganj, Khulna, Satkhira, Barishal, Patuakhali, Cumilla, Noakhali, Bandarban, Khagrachari and Rangamati etc.).

Benefit of the Technology

- Sugarcane crushing capacity of the developed BSRI power crusher is about 300-370 kg/hr while the capacity of conventional crusher is 300 -350 kg/hr
- Juice extraction capacity of BSRI developed power crusher is 55-68% of cane weight which is about 40-45% of cane weight for conventional crusher. So process loss about 10-20% can be reduced by using improved power crusher
- Weight is comparatively lighter (433 Kg) than the conventional crusher (510 Kg). Hence it can be carried easily to any long distances and in any remote areas of Bangladesh
- Fuel consumption rate of engine (10.5 hp) is comparatively less than conventional crusher engine (12hp)
- Production cost of goor is 35 Tk/kg through the developed power crusher which is 46 Tk/kg for the conventional power crusher
- Benefit cost ratio is 1.75 instead of 1.32 and payback period is 26 days in place of 38 days
- Machine durability is longer.

Researcher:

Sayed Shams Tabriz
Senior Scientific Officer
Agricultural Engineering Division
Bangladesh Sugarcrop Research Institute
Ishurdi-6620, Pabna.
Phone: +8801719862293, Email: tabriz_bsri@yahoo.com

Non-Chlorine Sanitizers for Safe and Quality Betel Leaf Production

Introduction

The presence of food borne pathogen especially salmonella and E. coli contamination in betel leaf represents a major threat from the point of public health and is emerged as an important export obstacle issue for Bangladesh that causes huge economical loss for the betel leaf farmers. Several factors like contaminated irrigation water, animal (wild and domestic) waste fertilizer, post-harvest washing by contaminated water, improper handling and storage, improper packaging, contamination from other foods in production area, sanitary equipment and facilities, ill workers etc. are responsible for the poor quality and unsafe betel leaf production. Cleaning and sanitizing practices should include standard post-harvest handling operations, which could substantially reduce the contamination of food borne pathogen in betel leaf and other food products. Chlorine has been widely using as sanitizer around the world but is being phased out in some countries due to health concerns. Chlorine reacts with organic matter to form highly carcinogenic trihalomethanes. Thus, Calcinated Calcium (Eco-Powder) is a potent may use as substrate of Chlorine. The use of calcinated calcium as a non - Chlorine sanitizers would be effective in eliminating food borne pathogens and improving the safety and quality of fresh betel leaves at farm level.

Description of the Technology

Integrated approach by combining pre and post-harvest good practices need to be followed for safe and quality betel leaf and other fresh food production. Calcinated Calcium is a baked and pyrolysis product of marine shell waste aggregate, white powder with no odor. It is natural, eco-friendly and biodegradable, which is proven as effective in killing bacteria, fungus and remove contaminants from the fruits and vegetables surface. Application of 0.01 of Calcinated Calcium (CaC) is recommended for washing fresh betel leaf to eradicate the pathogenic bacteria and fungi from its surface. The sanitized water is to be prepared by adding ¼ teaspoon of Calcinated Calcium (0.01 g/l) in 10 L tap water. The fresh betel leaf needs to be dipped into the sanitized water for 40-60 seconds with 1:10 ratio. It is suggested not to re-use the sanitized water, fresh sanitized water should be used for each batch of betel leaf. The sanitised betel leaf is to be transferred in a separate vessel for rinse using clean water for 40-60 seconds. The washed (sanitised) betel leaf is to be transferred in specific perforated tray to run off the excess water for 1 hour and then need to be dried using fan at room temperature or spin dryer for 4 hours. After drying, the dried betel leaves to be packed using hand gloves. The betel leaf package needs to be put in cold storage and during transportation cool temperature to be maintained till delivery.

Benefit of the Technology

- Safe betel leaves production for human consumption would be enhanced
- Farmers' income and livelihood would be increased
- Export resumption can be done

Researcher:

Md. Latiful Bari, Ph.D.
Center for advanced Research in Sciences,
University of Dhaka, Dhaka-1000, Bangladesh;
Tel: 8801971560560; Fax: 8802-8615583; E-mail: latiful@du.ac.bd

Optimization of Pre-Harvest Interval (PHI) of Commonly Used Pesticides in Some Vegetables

Introduction

Tomato, hyacinth bean, eggplant, cabbage and cauliflower are popularly grown as commercial crops in the country but those vegetables are highly prone to insect pest attacks. Pesticides are one of the major components of plant protection for the farmers due to its easy handling, storability and ample supply in the market. A considerable number of farmers sell vegetables immediately after spray or at an interval of 1-2 days after spray. Due to lack of proper knowledge on residual and detrimental effects of pesticides on human health and the environment, the farmers do not follow the prescribed dosages and use pesticides at any stage of the crop production. The sprayed fruits or vegetables are harvested without taking into account of the withholding period. Every pesticide has a withholding period or pre-harvest interval (PHI), which is defined as the number of days required to lapse, between the date of final pesticide application and harvest, for residues to fall below the tolerance level. Food products become safe for consumption only after withholding period has lapsed. The PHI differs from pesticide to pesticide and crop to crop. Considering the environmental condition the PHI has been re-set for dimethoate, fenvalerate and cypermethrin in the selected vegetables.

Description of the Technology

Tomato and hyacinth bean should be sprayed with the recommended dose of dimethoate (2mL/L of water) and fenvalerate (1mL/L of water) while eggplant, cabbage and cauliflower should be sprayed with the recommended dose of cypermethrin (1mL/L of water). The PHI is 10 Days after spray (DAS) for fenvalerate in tomato and 14 DAS in hyacinth bean; for dimethoate it is 10 DAS in tomato and 12 DAS in hyacinth bean. The PHI is 5 DAS in cauliflower and 4 DAS in eggplant and cabbage for cypermethrin.

Benefit of the Technology

- Farmers will get guidelines for harvesting safe vegetables and consumers will be benefited to get supply of save vegetables in the market
- Exporters and other stakeholders will be benefited from the technology through awareness building of safe and quality vegetables production

Researcher:

Dr. Md. Sultan Ahmed
Principal Scientific Officer
Entomology Division
Bangladesh Agricultural Research Institute, Gazipur-1701
Mobile: 01711 242901, E-mail: sultanpalbari@yahoo.com

Improved Cropping Patterns for Productivity Enhancement in Sylhet Region

Introduction

The average cropping intensity in Sylhet region is low (167%) compared to the national average (194%). A vast rainfed (non-irrigated) areas about 2.3 lakh ha remains fallow after harvest of T.Aman rice in rabi season due to lack of soil moisture. Cultivation of different rabi crops after harvest of T.Aman rice could be possible through certain agronomic interventions. Timely planting of short duration T.Aman rice, introduction of short duration HYVs of winter crops, relay cropping, utilization of residual soil moisture by reducing turnaround time after harvest of T.Aman rice are some of the options for harvesting rabi crops in Sylhet region.

Description of the Technology

Existing Cropping Pattern	Improved Recommended Cropping Pattern
T. Aus – T. Aman – Fallow	Wheat (BARI Gom 28) – T. Aus (BRRI dhan 48) – T. Aman (BRRI dhan 71)
T. Aus – T. Aman – Fallow	Mustard (BARI Sarisha-14) - T. Aus (BRRI dhan 48) - T. Aman (BRRI dhan 71)
T. Aus – T. Aman – Fallow	Wheat (BARI Gom-28/31) -Mungbean (BARI Mung-6) - T. Aman (BRRI dhan 71)
T. Aus – T. Aman – Fallow	T. aus – T. aman – Lentil (BARI Mashur-8) as relay crop

These improved cropping patterns are recommended for the sylhet region for higher production based on their agronomic suitability and user friendly. The improved cropping patterns are to be established using recommended doses of fertilizers as per FRG (Fertilizer Recommendation Guide) 2018, published by BARC. The recommended planting time of the crops in the pattern are: mustard last week of October to 1st week of November; wheat 2nd week of November and last week of March. Transplanting of T. Aus and T. Aman rice are 2nd week of May and 2nd week of August respectively. Lentil would be sown between 2-3 weeks before harvest of T. Aman rice as relay crops. Intercultural operations as well as plant protection measures are to be done as and when required. Lime (Dolomite) @ 1.5 t/ha has to be applied during ploughing i.e. 1-2 weeks before seeding. The suitable land type for the improved cropping patterns are medium high land of Sylhet region.

Benefit of the Technology

- Higher yield of BARI Sarisha- 14 (1150-1250 kg/ha), BARI Gom-28 & BARI Gom-31(3.5-4.0 t/ha), BARI Mung-6 (1.5-1.7t/ha), BRRIdhan-48 (3.25-3.52 t/ha) and BRRI dhan71 (4.0-4.25 t/ha) could be obtained under residual soil moisture
- About 60-70 % higher Rice Equivalent Yield would be obtained due to inclusion of Mustard, Wheat and Mungbean in Fallow- T. Aus-T. Aman Cropping Pattern
- Higher gross return (255800- 280500 Tk/ha/year), gross margin (145500-170300 Tk/ha/year) and BCR (2.32-2.55) could be obtained in Improved Cropping Patterns over Existing Cropping Pattern

Researcher:

Dr. Dilwar Ahmed Choudhury
Principal Scientific Officer
Director General's Office, BARI, Gazipur
Phone: +88-02-49270185, Cell: 01711318685,
E-mail: dilwar92@yahoo.com

Integrated Pest Management (IPM) for Sustainable Tea Production

Introduction

Tea is a major cash crop as well as an export commodity of Bangladesh. Tea plants are subject to attack of insects-pests, mites, nematodes etc. and weeds that caused about 10-15% crop loss. To combat these losses different groups of chemical pesticides like organochlorine, organophosphate, pyrethroids, carbamates and some unclassified groups are used in tea fields. Chemical pesticides have serious drawbacks, such as direct toxicity to beneficial insects, fishes and human. It induces resistance to the pests, health hazard and increased environmental, social costs. Therefore, managing these pest populations within economic threshold level through Integrated Pest Management (IPM) system is imperative.

Description of the Technology

IPM techniques include resistant clone, cultural, mechanical, plant extracts, bio-control agents and bio-pesticides. Numbers of resistant clones (BT1, BT2 & BT15 for Helopeltis, BT5, BT6 & BT17 for red spider mite and BT3, BT4, BT8, BT9, BT12, BT13, BT14, BT15, BT18, BT19, BT20 for thrips) released by BTRI for planting in the respective pest prone areas. Light Pruning (LP) @ 55 cm, could be followed in tea garden during December-February to reduce pest infestation. Plucking should be done at 7days interval to reduce the incidence of Helopeltis. Weeding should be done periodically for reducing pest population (red spider mite). Solar power light trap at night attracts the flying pests of tea. UV lights (220 V, 18 W, 5.2 nm; make – Actinic blue, Philips) in the light traps are to be used. The light frame should be horizontally mounted on a bamboo pole and placed 1.15 m above the ground. Two light traps in pair are to be placed approximately 600 m apart. Yellow sticky trap is to be placed in the infested sections of the tea garden. Bright yellow colour corrugated plastic boards can be cut into small pieces (12" x 12") and both sides coated with a thin film of an adhesive which can serve as sticky material. For collecting thrips and green hoppers, simply a hole need to be punched at the top of the trap and hang it with a string. The Yellow sticky cards traps should be placed in the tea field above the bush canopy (plucking table) at an angle 60° facing against wind by securing them on top of bamboo sticks. For moderate infestation, 8 Yellow Sticky Traps ,for heavy infestations, 10 traps per 1000 m2 are to be placed. Total 80-100 traps are required/ha. Traps should be checked at least twice a week. Botanicals/ Plant Extracts: Fresh leaves, succulent stems, seeds of Akonda, Basok, Bishkatali, Datura etc. have strong insecticidal properties and extract of these plants can be used as an alternative to chemical pesticides for minimizing the pests of tea. Bio-control agents: Bracon hebetor as a larval parasitoid @ 5 adults/30 larva is effective against Looper caterpillar infesting tea. About 2000-5000 adult Bracon is needed/ha for effective control of looper caterpillar. Bio-pesticides: Two microbial pesticides viz., *Metarhizium anisopliae* and *Pseudomonas fluorescensis* used @ 1.0 ml/L water against red spider mite. Bacillus thuringiensis@ 1.5 g/L water is also effective against looper caterpillar. For effective control of looper caterpillar, second round should be sprayed at 7 days interval

Benefit of the Technology

- IPM significantly reduce the risk of pesticide and chemical load on tea as well as improve quality, health and welfare of the environment
- Promotes sustainable bio-based pest management alternatives in pest management program in the tea garden
- Protects non-target species and reduces or eliminates issues related to pesticide residue in table tea
- Maintains or increases the cost-effectiveness of pest management program.

Researcher:

Dr. Mohammad Shameem Al Mamun
Senior Scientific Officer (Entomology)
Bangladesh Tea Research Institute Sub Station
Bangladesh Tea Board, Dhakkamara, Panchagarh.
Cell No.: 01712119843, Email: kbdshameem@gmail.com

Improved Cropping Patterns for Productivity Enhancement in Enclaves (Sit mahal) of Northern Bangladesh

Introduction

The farm households of earlier enclaves (Sit mahal) are still dependent upon the traditional agricultural practices, which could be considered as major hindrance for improvement of crop productivity. Being detached from the mainland for about 68 years, the inhabitants of enclaves are engaged only in subsistence farming with low agricultural productivity with restricted access to improved technologies. The National Agricultural Research Institutes (NARIs) have developed a number of excellent improved technologies including high yielding varieties and balance fertilization methods, which may be the good options for enhancing crop productivity in the enclaves (sit mahal).

Description of the Technology

- Some improved cropping patterns with additional suitable crops and improved varieties have been recommended for the enclaves after extensive trials under CRG programs of NATP phase II. The improved cropping patterns with varieties are shown in the following table against the existing cropping patterns.

Existing Cropping Pattern	Improved Cropping Pattern (Technology)
T. Aman (var: Swarna) – Fallow – Boro (var: BRRI dhan28)	T. Aman rice (var: BRRI dhan49) – Mustard (var: BARI Sarisha-14) – Boro (var: BRRI dhan58)
T. Aman (var: Swarna) – Potato(var: Lal Pakri) – Boro (var: BRRI dhan28)	T.Aman (var: Binadhan-17) – Potato(var: BARI Alu-46) – Jute(var: O-795)
T. Aman (var: Swarna) – Potato(var: Lal Pakri) – Boro(var: BRRI dhan28)	T.Aman (var: BRRI dhan49) – Potato(var: BARI Alu-46) – Maize(var: BARi Hybrid Maize-9)

The improved cropping patterns are to be established using recommended doses of fertilizers as per FRG (Fertilizer Recommendation Guide), 2018, published by BARC. The recommended planting time of all crops in the pattern (Mustard, Jute, Maize and Potato are: 2nd to 3rd week of November, 2nd to 3rd week of April, 1stto 2nd week of March and 3rdto 4thweek of November respectively) are to be followed. Transplanting of T. Aman and Boro rice are to be made in 1stweek of August and 2nd to 3rdweek of February respectively. The suitable land types for the improved cropping patterns are medium low land to medium high land of Northern Region of Bangladesh.

Benefit of the Technology

- Higher rice equivalent yield (102%) and gross margin (150%) could be obtained from T. Aman --Mustard-Boro cropping pattern than the existing practices
- Higher rice equivalent yield (74%) and gross margin (134%) could be obtained from T. Aman – Potato--Jute cropping pattern than the existing practices
- Higher rice equivalent yield (71%) and gross margin (73%) could be obtained from T. Aman – Potato --Maize cropping pattern than the existing practices
- Mustard variety (BARI Sarisha-14) and potato variety (BARI Alu-46) are high yielder but BARI Alu-53 (red skin) is more profitable and preferable.

Researcher:

Dr. Md. Samim Hossain Molla,
Senior Scientific Officer,
On-Farm Research Division,
Bangladesh Agricultural Research Institute, Alamnagar, Rangpur,
Cell phone : +8801716595677, E-mail :samimmolla@yahoo.com

Introduction of High Value Vegetables in Sylhet Region

Introduction

Sylhet region is good for hill agriculture (tea and citrus production) but comparatively poor in plain land agriculture. In Sylhet region seasonal fallow land is the highest than any other parts of the country. The low production of vegetable in Sylhet region is mostly attributed by: low irrigation coverage, prevalence of acidic soil, less interest of farmer in agriculture, lack of suitable variety along with production technology, lack of research on vegetable crops etc. The promising vegetable crops are tomato, country bean, French bean, radish and broccoli. The low acreage/hectarage and production of these vegetable crops in Sylhet region can easily be increased through appropriate intervention with variety and production technology. BARI and Sylhet Agricultural University recommended some high yielding varieties along with production technologies for these vegetables during winter and summer season, adoption of those technologies can possibly make a breakthrough in Sylhet region.

Description of the Technology

Photo-insensitive country bean genotype 'Sikribi sheem-1' is suitable for cultivation in trellis or staking support systems during summer for higher yield (40-45 kg/decimal) in the region. Seeds of 'Sikribi sheem-1' is to be sown in 2nd to 3rd week of May in raised bed maintaining plant to plant and row to row distance 1.0 m and 2.0 m respectively. Grafted summer tomato seedlings of BARI Hybrid Tomato-8 could be cultivated under polythene tunnel during summer for producing higher yield (50-55 kg/decimal) as well as increased income in Sylhet region. About 30 day old grafted (grafted on to S.ysiimbrifolium) summer tomato seedlings need to be transplanted in the last week of August maintaining 60 x 40 cm spacing between row to row and plant to plant distance for producing bacterial wilt free plants and higher yield (58 t/ha).BARI Hybrid Tomato-5 could be grown well during winter with higher yield (94 t/ha) in Sylhet region.30 days old seedlings of BARI Hybrid Tomato-5 need to be transplanted in the 2nd week of November maintaining 60 cm x 40 cm spacing of row to row and plant to plant .BARI Jarsheem-1 can be cultivated in October for producing higher yield (75 kg/decimal) while broccoli genotype Centaru may be cultivated during last week of November (seedling transplant) for higher yield (109 kg/decimal). Manure and fertilizers should be applied as per recommendation of Fertilizer Recommendation Guide, 2018.Intercultural operations as well as spraying of insecticides and fungicides should be done as when required.

Benefit of the Technology

- Higher yield of Sikribi sheem-1 (40-50 kg/decimal), Hybrid Tomato-8, (50-55 kg /decimal), BARI Hybrid Tomato-5 (90-95 t/ha), Broccoli genotype Centaru (90-100 kg/decimal), BARI Jarsheem-1 (75- 77 kg/decimal) could be obtained in Sylhet region
- Higher BCR of Sikribi sheem-1 (3.40), BARI Hybrid Tomato-8(2.42), BARI Jarsheem-1 (2.1) and Broccoli genotype Centaru (4.18) could be obtained.

Researcher:

Dr. Md. Shahidul Islam
Professor, Department of Horticulture
Sylhet Agricultural University, Sylhet.
Mobile: 01916662421, E-mail: shahidulhrt@gmail.com

Integrated Management of Major Insect Pests of Soybean

Introduction

Soybean (*Glycine max* L.) is one of the most important crops in Bangladesh and is extensively cultivated especially in Noakhali region. Seeds of soybean contain about 42% protein and 20% oil and provide 60% of the world supply of vegetable protein and 30% of the edible oil, which is very popular in Bangladesh. Recently the crop has gained popularity due to development of poultry industry and cultivation is gradually expanding. Cultivation of soybean covered about 55,000 ha that produced about 90,000 MT of seeds. Several major insect pests attack soybean crop and cause considerable loss (about 25%), and insect damage is a limiting factor for its successful production. But most of the major insects appear and infest the crop (about 100%) during vegetative to flowering stage (30-50 DAS) causing about 30% yield loss in soybean. Farmers put less attention to control insect pests due to lack of Integrated Pest Management (IPM) technologies. Farmers can reduce pest damage (80%) by adopting eco-friendly IPM technologies.

Description of the Technology

Use of chemical insecticides does not always properly control insects, especially leaf rollers and cutworms. Besides, misuse and overuse of the insecticides cause phyto-toxicity of the plant, create environmental pollution and human health hazards. Use of IPM like combination of hand picking, perching, clean cultivation, netting, pheromone trap and bio-controlling agents etc. as and when necessary in soybean cultivation reduces pest infestation by 80%, management cost by 30%, and increases seed production by 20-30%. Use of IPM package: hand picking + sex pheromone + perching + Bt powder + spinosad (Success 2.5 SC @ 1.2 ml/L of water) is recommended for reducing the population of common cutworm by 83%, leaf roller by 75% and hairy caterpillar by 76% and as a whole, plant and leaf infestation by 82% in soybean.

Benefit of the Technology

- IPM technology supports higher yield of soybean (2.25 t/ha)
- IPM technology (Hand picking + Perching + Sex Pheromone trap + Bio-control agent) reduces insect population by 93% and their infestation by 80-90%
- IPM increases soybean yield by 30% over traditional insect control measures
- Net incomes from soybean cultivation generally reach to Tk 40000/ha when IPM is used.

Researcher:

Dr. Gobinda Chandra Biswas
Principal Scientific Officer (Entomology)
Planning and Evaluation Wing,
BARI, Joydebpur, Gazipur
Phone: 9294100, Mobile:01715626431
E.mail: gbiswas_bari47@yahoo.com

Bio-rational Management of Fruit Flies of Fruits and Vegetables

Introduction

Fruit flies, Bactrocera spp. are among the most economically important insect pests in Bangladesh attacking a wide range of fruits and vegetables. Numerous fruit fly species constitute enormous threats to fruit and vegetable production causing both quantitative and qualitative losses. Mainly two species of Bactrocera are present in Bangladesh, B. cucurbitae, infesting 16 cucurbitaceous vegetables and B. dorsalis, infesting different fruits. Good achievements have been made in developing and popularizing pheromone based Integrated Pest Management (IPM) technologies against fruit fly in vegetables and fruits, but resurgence of new species is causing hindrance for its cost effective management. So, a bio-rational based sustainable management considering the species complex and their host range is developed.

Description of the Technology

The effective management option of fruit fly species complex is sanitation (destruction of infested fruits from the soil) + attract and kill method (setting of culure pheromone lures at the border areas at 10 m distance and female attractant in the inner rows at 12 m distance). As fruit fly infestation is not done only with one species, rather species complex is responsible for the fruit infestation and yield loss, so appropriate management option(s) could be undertaken addressing all the species. In that respects attract and kill method is an effective and economic management option. The inputs have already been registered and available in the market as a commercial product. Three major species Bactroera dorsalis, B. tau, B. cucurbitae are found. B. dorsalis outnumber all other species and can be considered as the most prevalent species of fruit flies in Bangladesh. Low infestation by fruit fly complex and healthy fruit yield of different fruits ensured by bagging of fruits with polythene, followed by sanitation + attract and kill method within one month of fruit set/ seed sowing and sanitation + pheromone (culure) mass trapping in water trap.

Benefit of the Technology

- IPM practices reduce 85% fruit (mango) infestation that results 43% yield increase of healthy fruits
- Lower (3%) insect infestation in cucurbits/gourds (vegetables) and higher yield (22.70 t/ha) could be obtained with the use of the technology (sanitation + attract & kill method within one month of fruit setting /seed sowing) + application of soil recharge (microbial pesticide to destroy pupa) followed by sanitation + attract & kill method, only attract & kill method, sanitation+ pheromone (culure) mass trapping in water trap + soil recharge, sanitation + pheromone mass trapping.

Researcher:

Dr. Syed Nurul Alam
Director, Planning and Evaluation Wing and
Ex Chief Scientific Officer & Head
Entomology Division
Bangladesh Agricultural Research Institute
Joydebpur, Gazipur, Bangladesh
Mobile: 01711 907886, E-mail: alamsn09@gmail.com.

Eco-friendly Management of Sucking Insects in Cotton

Introduction

Cotton is a cash crop in Bangladesh and believes to be a pest loving crop. Sucking pests are quite serious from seedling stage of cotton. Heavy infestation reduces the crop yield to a great extent. The estimated loss due to sucking pests is up to 21%. Among the sap feeders, jassid (Amrasca biguttula), aphids (Aphis gossypii) and whitefly (Bemisia tabaci) are serious pests. Climate is an important determinant of the abundance and distribution of sucking insects. Climate affects their development, reproduction, and dispersal. Change in the global climate may thus affect the crop yields, incidence of pests, and economic costs of agricultural production. Cotton farmers in Bangladesh depend largely on synthetic pesticides to control sucking pests. At least 5-7 chemical sprays are directed against sucking pests. Due to continuous use of synthetic insecticides, insects become resistance and hence the efficacy becomes less reliable. Indiscriminate use of insecticide especially for jassid, aphid, white-fly, red cotton bug causes environmental pollution. Incremental uses of toxic chemicals take place in the food chain and ecosystem through bio-magnification and cause hazards. Bio-chemicals are effective and have less exposure in the environment. Azadiractin is a bio-chemical with active ingredient of neem which is suitable for many crops. Akondo leaf extract (50%) + Tobacco leaf extract (50%) is an example of bio-pesticide.

Description of the Technology

- Application of Azadiractin (Bioneem plus 1% EC) @ 1 ml/ L of water + Yellow sticky trap + Spinosad (Success 2.5 SC) @ 1 ml / L of water effectively controls jassid population in cotton field
- Application of Azadiractin (Bioneem plus 1% EC) @1ml/L of water + Yellow sticky trap controls whitefly and ensure higher yield. The technology is environment friendly
- Use of botanical pesticides in cotton would help not only to control the insect pests, but also to save the natural enemies i.e. predators etc. and to protect the environment from pollution due to synthetic pesticides

Benefit of the Technology

- Higher gross margin (Tk. 101576) and Benefit Cost Ratio (2.85) could be obtained with the use of Azadiractin (Bioneem plus 1% EC) @ 1 ml/ L of water + Spinosad (Success 2.5 SC) @ 1 ml / L of water + Yellow sticky trap.

Researcher:

Md. Akhtaruzzaman
Additional Director (Research)
Cotton Development Board,
Khamarbari, Farmgate, Dhaka-1215.
Mobile: 01819724670, Email: ak.zaman@yahoo.ca

Integrated Management for Major Insect Pests and Diseases of Chilli

Introduction

Chilli (*Capsicum frutescens*) is the most important spices crops in Bangladesh. Green chillies are rich sources of antioxidants and vitamin A and C. Economic yield loss may occur 11-75% quantitatively and 60-80% qualitatively due to serious damage by insects and diseases. Anthracnose caused by Colletotrichum sp. is a major problem in chilli, which may cause yield loss up to 50%. Different sucking pests like mite, thrips, jassid, aphids and caterpillars are the major constraints for chilli production. The chilli crop suffers from the attack of a number of fungal, bacterial and viral diseases. Among the fungal diseases damping off, choenaphora and anthracnose are the major devastating diseases causing considerable yield loss. In order to promote the supply of safe spice (chilli) for both domestic and export market, Integrated Pest Management (IPM) technology needs to be disseminated through farmers community approach (FCA), mass media campaign, demonstration, training etc. Major emphasis is urgently needed to find out the major insects and diseases and their management approaches through bio-control agents, bio-pesticides, mechanical and cultural practices.

Description of the Technology

- Spraying of Spinosad (Success 2.5SC) and Abamectin (Toximite 1.8 EC) along with blue and yellow sticky traps is recommended for effective control of sucking insect pest in chilli. Mass trappings of Spodoptera litura and Helicoverpa armigera + spraying of SNPV and HNPV along with Spinosad are need to be used for effective control of borer complex of chilli. Alternate sprayings of Carbendazim (Autostin) and Pyraclostrobin + Metiram (Carbio Top) along with seed treatment is recommended for effectively control the wilt disease of chilli. Spraying of Tebuconazol +Trifloxistrobin (Nativo) @ 0.6g/L of water is very effective for controlling anthracnose and choanephora disease in chilli.

Benefit of the Technology

- The effective control of sucking insects will result regular good harvest of quality chilli with higher profit margin compare to sucking insects affected fields
- Borer control would produced higher yield of chilli and ensures higher margin for the farmers
- The control of wilt and anthracnose will ensures higher yield and economic margin for farmers by cultivating chilli. The use of the technology will help farmers to grow quality crop, and would ensure higher market price by inducing export of chilli in foreign countries.

Researcher:

Dr. Md. Abdul Mannan,
Principal Scientific Officer,
RARS, BARI, Jamalpur,
Mobile: 01913-209957, e-mail: mannanbari83@gmail.com

Bagging Technology for Safe and Quality Mango Production

Introduction

Mango (*Mangifera indica* L.) is one of the most important commercial fruits and choice fruits for people of all age groups of the country. About 41676 ha land is occupied with mango orchard with a production of about 12.88 lac MT. Mango fruits and trees are subject to attack of several animate and inanimate diseases. The outbreaks of different mango diseases and attack of insect pests reduce the yield. To control these problems farmers spray pesticides 15-62 times in their mango orchard. Because of favorable environment during fruit maturity, mango fruit fly is a major pest that damages huge quantity of mango fruits every year. Bagging protects fruit from insects, diseases, mechanical damage, reduces spraying of insecticides and provides good amount of harvestable fruits per tree. It is an efficient, safer and cheaper method for controlling mango insects and diseases. Bagging technology is being used for preventing destruction of fruits by birds, insects, diseases and thus to produce high-quality fruits. Pre-harvest bagging is a physical protection method which improves the visual quality of fruits by promoting skin color and internal fruit quality. Pre-harvest bagging of fruit can also reduce the incidence of disease, insect, mechanical damage, sunburn of the skin, fruit cracking, agrochemical residues on the fruits and bird damage. Adoption of bagging technology in mango production would produce safe and quality fruit with minimum spraying of pesticides.

Description of the Technology

- Fruit bagging is being practiced not only in mango but also in apple, pear, peach, longan to improve the commercial value. Uses of different materials especially brown paper double layered bag and white paper single layered bag improve physico-chemical properties and shelf life of fruits. It increases fruit weight and size over non-bagged control fruits. Banging also extends the harvesting time.Bagging effectively improves fruit quality such as physical, chemical and microbial properties. The variation observed in chemical composition of mango fruits can be attributed to the changed microenvironment around fruit during its growth and development. The longer shelf life of mango is achieved when double layer brown paper bag being put at 35 days of fruit set. Fruit bagging of mango with double layered brown paper bag at 35 days of fruit set is recommended for producing safe and high quality fruits.

Benefit of the Technology

- Safe and quality mango fruits could be produced with the use of double layered brown paper bags at 35 days of fruit set
- Bigger fruits having longer shelf life (15 days) could also be obtained by double layered brown paper bag at 35 days of fruit set.

Researcher:

Prof. Dr. Md. Tariqul Islam
Dept. of Horticulture
Hajee Mohammad Danesh Science and Technology University, Dinajpur
Mobile No. 01716017557, E-mail: tariqulhstu@gmail.com

Management of Bacterial Diseases of Silkworm

Introduction

Sericulture is an agro-based enterprise highly suited to small and marginal farm holdings with less capital investment. Cocoon production involves mainly two distinct activities, mulberry leaf production and silkworm rearing. Silkworms are infected with a number of bacterial diseases, which affect the cocoon quality and productivity resulting in economic loss to the farmers. In Bangladesh, there are four major commercial silkworm rearing and cocoon production season/months like Jaistha, Bhaduri, Agrahyani and Chita. Bacterial disease mostly occurs in Jaistha and Bhaduri season and damages 20-40% cocoon production. Bacterial diseases are popularly known as 'Flacherie' due to the flaccid nature of the diseased larvae. For minimization of losses due to bacterial diseases, it is very essential to know the growth pattern of bacteria and their control measure.

Description of the Technology

- In Bangladesh there are four genera of bacteria: Bacillus subtilis, Streptococcus pnumoniae, Staphylococcus spaureus and Bacillus thuringiensis cause diseases in silkworm. Topical application of the effective bed disinfectant can be utilized as an effective prophylactic measure against occurrence of these bacterial diseases. Use of bed disinfectants with bleaching powder or parafomaldehyde could successfully control the bacterial diseases and reduces the mortality of silkworm larvae. The silkworm rearing tray treated with bleaching powder (2%) would helps to increase survival rate (76%) of silkworm. Treatment with Paraformaldehyde (2%) could also reduce the bacterial growth and improves the survival rate of silkworm. The combinations of different formulations with lime are also very effective against bacterial diseases of silkworm. Silkworm mortality can effectively be minimized by feeding tender leaf of mulberry; matured or water soaked or preserved leaves increases bacterial growth and increases mortality. Similarly low population (100/1200 cm^2) per tray reduces mortality by bacterial diseases.

Benefit of the Technology

- With the decrease of mortality of silkworm the cocoon production would be increased and the income by rearing silkworm is expected to be increased by 20-30% with minimum efforts i.e. by using disinfectants (bleaching powder or paraformaldehyde)
- Selection of mulberry leaves for feeding of silkworm would increase the production of cocoon and silk
- The technology of using disinfectants and reducing silkworm population in the rearing tray would certainly increase yield of cocoon per batch of rearing and income of farm households per unit area per unit time.

Researcher:

Md. Aftab Uddin
Research Officer
Bangladesh Sericulture Research and Training Institute.
Baliapukur, Padma Abasik., Rajshahi-6207.
Mobile: 01719036851, E-mail: aftabbsrti@gmail.com

BARI Sujamikhi-2: A Promising Salt Tolerant Variety

Introduction

In Bangladesh, acute shortage (71-74%) of edible oil has been prevailing during the last decades. This shortage inherited from the past has been met through imports, spending a huge amount of foreign currencies every year. Only 4% land in Bangladesh are occupied with all oilseed crops. Out of 2.83 million hectares of the coastal areas of Bangladesh about 0.88 million hectares are affected by salinity. This vast land remains mostly uncultivated except some selected areas where farmers grow mostly low yielding traditional crops. Thus, there is a great scope to enhance sunflower (Helianthus annuus L.) production in this saline area by adapting salt tolerant sunflower genotypes. Its oil is highly nutritious containing antioxidant, vitamin, minerals and fatty acids. It is one of the most important crops grown for oil in both rabi and kharif seasons and it's seeds contain about 40-45% oil and protein about 22-24%.However, till now, no such variety has been developed for the areas due to complexity of salinity tolerance trait. Therefore, it is essential to develop a salt tolerant sunflower variety to cultivate in saline areas which could ultimately increase total area and production of oilseeds in the country and helps to reduce the existing gap between production and consumption of edible oil.

Description of the Technology

- BARI Surjamukhi-2 is recommended for cultivation in the saline area up to 12 dSm-1salinity level to increase the production of sunflower in the country
- Oil and mono unsaturated fatty acid content of these two genotypes are varies from 40-48% and 44-60%, respectively
- Seeds sowing time of BARI Surjamukhi-2 are mid November to mid December. life cycle 95-100 days respectively. The seed rate is 11 - 13 kg/ha
- Manures and fertilizers should be applied as per recommendation of Fertilizer Recommendation Guide, 2018
- Intercultural operations as well as spraying of insecticides and fungicides need to be done as and when required
- Suitable areas would be the coastal areas of Bangladesh

Benefit of the Technology

- BARI Surjamukhi -2 could be cultivated under the saline areas up to 12 dsm^{-1} salinity level for increasing production of oilseeds in the country
- There would be an ample scope to improve the existing cropping system / pattern in the coastal areas for increasing the farmers income.

Researcher:

Dr. Md. Shakhawat Hossain
Senior Scientific Officer
Central Laboratory, Oilseed Research Centre
Bangladesh Agricultural Research Institute, Gazipur
Mobile: 01781539300. Email- shakhawatbari@yahoo.com

BARI Sarisha-16: A Promising Salt Tolerant Variety

Introduction

In Bangladesh, acute shortage (71-74%) of edible oil has been prevailing during the last decades. This shortage inherited from the past has been met through imports, spending a huge amount of foreign currencies every year. Only 4% land in Bangladesh are occupied with all oilseed crops. Out of 2.83 million hectares of the coastal areas of Bangladesh about 0.88 million hectares are affected by salinity. This vast land remains mostly uncultivated except some selected areas where farmers grow mostly low yielding traditional crops. Thus, there is a great scope to enhance mustard (Brassica sp) production in this saline area by adapting salt tolerant mustards genotypes. Salinity at its various concentrations may affect mustard plants at any stage of growth. In addition, Brassica has some potential to cope with the toxicity of salts. However, until recent, no mustard genotypes have been developed tolerant to salinity. Therefore, it is essential to develop a salt tolerant mustard variety to cultivate in saline areas which could ultimately increase total area and production and consumption of edible oil in the country and helps to reduce the existing gap between production and consumption of edible oil.

Description of the Technology

- Mustard variety BARI Sarisha-16 is recommended for cultivations in the saline area up to 12 dSm-1salinity level to increase the production of mustard in the country
- Oil and erucic acid content of this variety varies from 45-48%
- Seeds sowing time of this variety Sarisha-16 and BARI Sarisha-11 are 1st - 2nd week of last week of October to - 2nd week of November, having a life cycle of almost 100 days (varies from 95 to 105 days). The seed rate for all these genotypes are 6 - 7 kg/ha^{-1}
- Manures and fertilizers should be applied as per recommendation of Fertilizer Recommendation Guide, 2018
- Intercultural operations as well as spraying of insecticides and fungicides need to be done as and when required
- Suitable areas would be the coastal areas of Bangladesh.

Benefit of the Technology

- Mustard variety, BARI Sarisha-16 could be cultivated under the saline areas up to 12 dsm^{-1} salinity level for increasing production of oilseeds in the country
- There would be an ample scope to improve the existing cropping system / pattern in the coastal areas for increasing the farmers income

Researcher:

Dr. Md. Shakhawat Hossain
Senior Scientific Officer
Central Laboratory, Oilseed Research Centre
Bangladesh Agricultural Research Institute, Gazipur
Mobile: 01781539300. Email- shakhawatbari@yahoo.com

Healthy Seedling Raising of Boro Rice Against Blight Disease

Introduction

High mortality as well as slow growth of seedlings both in trays and fields is observed due to severe infection of seedling blight in cold environment during dry (Boro) season. Short seedlings cannot be used in rice transplanter. Mechanical transplanting is not expanding, transplanting is delaying and disease infection put the farmers in difficulties for raising seedlings further at mid or late season. Consequently, crop yield is hampered and farmers have been experiencing economic loss. Therefore, development of a complete method of raising healthy mat type seedlings both for mechanical/manual transplanting would be beneficial.

Description of the Technology

- Seeds need to be treated with Azoxystrobin+Difeconazole, Pyraclostrobin or Azoxystrobin @ 0.2-0.3% for 18-20 hrs and incubated for germination
- Sprouted seeds should be sown in trays containing pulverized loam/sandy-loam soil and covered with a thin layer of the same soil
- Immediate after sowing and subsequent irrigation, the trays should be covered with polythene continuously for 72 hrs and then regularly from afternoon to the next morning
- Irrigation need to be applied 2-3 times a day
- A mixture solution of 1-2% urea, 0.6% MoP, 0.2% sulphur and 0.2% $ZnSO_4$ need to be sprayed at 5-7 days after sowing is useful for nutrient management
- Alternatively, NPK at 2-3, 3-4 and 2-3 gm/tray soil respectively can be mixed with soil before tray preparation
- Instead of seed treatment, fungicide (Amistertop 325 SC) spraying on the cover soil in trays at immediately after seeding or upto 3 days after seeding is equally effective for controlling seedling blight disease. Healthy seedling (3-4 leaf age, 12-13 cm long) can be raised within 26 days and used both for mechanical and manual transplanting

Benefit of the Technology

- Ensure management of devastating seedling blight and other seedling diseases
- Growing good quality seedling for mechanical/manual transplanting would be possible
- Ensure vigor and younger seedlings which enhance crop yield that supports food security and sustainability
- Raising seedling in trays at farmer's yard will make the field free from using for seedbed and hence increase crop intensification
- Adoption of this precision technology will enhance mechanization of rice farming
- Finally, all the beneficiaries such as rice farmers, commercial entrepreneurs and seed producers would be benefited using this technology in the cold affected areas.

Researcher:

Dr. Tahmid Hossain Ansari
PSO, Plant Pathology Division
BRRI, Gazipur-1701
Mobile: 01716-839404; Email: tahmidhansari@yahoo.com

Ankuri- A Healthy Rice Seed Germinator and Disinfector

Introduction

Farmers generally using a risky traditional Zaag-method for germinating rice seeds. Poor germination or even germination failure is a general scenario in this method. A large part of Bangladesh especially the northern and north-western region is generally affected with low temperature that largely affects seed germination in dry (Boro) season. The low temperature reduces seed germination. Incubation temperatures strongly affect the germination which could not be maintained in Zaag method. Thus the Zaag-method in association with low temperature during Boro season hampers seed germination. The ultimate results are loss of seeds or seedlings and high expense of the farmers. Generally, 20-30% seed or sometimes complete germination failure has been observed because of traditional Zaag-method. Ankuri a vapor induced healthy seed germination and seed disinfection technique has been developed to solve the problem.

Description of the Technology

- A plastic bucket having inside a steel frame, sensor and water heater controlled by an auto control box to be used in Ankuri seed germinator
- It is a vapor induced healthy seed germination technique in cold environment
- Around 40-50 liter of water need to be taken in the bucket
- Then loosely packed seeds in a sac should be kept on the frame inside the bucket water and covered with the lid. Temperature indicator need to be set at 30-32^{0}C for 20-24 hours in the auto-control box and connected with electricity
- When water temperature is adjusted to the set temperature, the heater to be disconnected and re-started-on automatically for heating water immediately after the set temperature goes down
- The green light becomes 'ON' when the heater started for heating and becomes 'OFF' when the heater goes off
- After 20-24 hours, some water from the bucket need to be drained out so that the water level is below the steel frame but must be considerably above the heater
- Soaked seeds should be kept again as before on the steel frame in the bucket covered with its lid and connected with electricity. Vapor is generated from water and keeps inside the bucket environment with high humidity and expected set temperature. Under this environment seed can be germinated within 3 days
- Electric connection should be disconnected whenever any operation is done inside the bucket
- Seeds which are soaked outside the bucket, can also be germinated using Ankuri
- Temperature and humidity are auto-controlled which cannot be done in Zaag method

Benefit of the Technology

- Minimize at least 15% seed loss, germination is ensured and faster and completed within 60 hours as compared to 120 hours in Zaag method
- It can be used for disinfection of seeds and hence less seedling disease
- Farmers, seed producers, researchers and even seed traders will be benefitted using this technology
- Eventually, adoption of this precision technology will minimize the germination failure and support agricultural mechanization as a whole.

Researcher:

Dr. Tahmid Hossain Ansari
PSO, Plant Pathology Division
BRRI, Gazipur-1701
Mobile: 01716-839404; Email: tahmidhansari@yahoo.com

BRRI Head-Feed Mini Combine Harvester

Introduction

The rice straw is used as cattle feed, fuel for cooking and packing material of different industries. Farmers get a handsome amount of money by selling straw and that's why straw is an important issue of farm mechanization. The head-feed mini combine harvester provides that advantage to keep straw intact which can be used for beneficial purposes. Imported harvesters are in big size and cannot be handled properly in small plot. In addition, there is no suitable farm road for easy accessibility. Furthermore, agricultural soil of Bangladesh is alluvial type and load bearing capacity is low, that's why big machine cannot be operated in the farm smoothly. Therefore, a simple mini combine harvester (cutting width 1.2m - 1.5m) has been designed and fabricated seems to be the most suitable in Bangladesh condition.

Description of the Technology

- BRRI Head Feed Mini Combine Harvester is a (diesel engine driven) machine which accomplishes major four functions (reaping, threshing, winnowing and bagging) of grain harvest in a single operation
- This machine to be used for those crops whose sheath/panicles is at the top of the plant and the lower part which is discarded or left in the field as chaff. The included crops are paddy, wheat, barley etc
- Crops should be harvested at 80% maturity to avoid shattering loss
- If the ridge is too high and there is no space to discharge straw then around 0.5 m is to be cut surrounding of the plot
- The machine can cut up to 65-130 cm height plant. If the crop height is more than 130 cm, then header should be adjusted as above as possible and for below 65 cm plant height, header should be fixed as below as possible.
- If crop is lodged more than 600 angle then it is to be cut from opposite direction of lodging at slow speed
- The crops should not be harvested with dew or much moisture. Otherwise, the concave screen may be damaged and cannot clean the grain
- The field should be checked around and any miscellaneous objects such as stone, perching material, steel plate, reed and wood pile are to be removed before operation
- The four corners of the plot (2 x 2 m size) should be harvested by hand for easy movement of the machine
- The machine should be operated as straight as possible
- Field capacity: 0.15 – 0.20 ha/hr
- Engine: 32 hp diesel engine
- Fuel consumption: 3.73 – 4.00 l/hr
- Price: Price depends on quality of materials used and production system
- Approximate price Tk 5.0 lakh

Benefit of the Technology

- It can be operated on both dry and muddy fields with a plough pan up to 15– 20 cm
- Reaping, threshing, winnowing and bagging can be done in single operation
- Minimum harvest loss is around 2.46%

Researcher:

Bidhan Chandra Nath
Senior Scientific Officer
Bangladesh Rice Research Institute, Gazipur.
Mobile: 01712-580273; E-mail: bidhanbrri@gmail.com

BRRI dhan 91-: A High Yielding Tall Deep Water Rice Variety

Introduction

Rice production could be increased through increasing yield of a variety and its area coverage particularly in deep water rice (DWR) areas to enhance food security of the country. Due to climate change, threat of extreme flooding or threat of drought is too much in million hectares of land. There are about a million ha areas are remaining fallow under shallow flooded up to 1 meter height of water. In those areas, no crops other than DWR are possible to grow. In view of this, multi-stress tolerant variety resilient to climate change need to be developed - which could give higher yield under early drought and shallow flooding condition. But in local deep water, tallness is negatively correlated with yield; it is difficult to develop tall modern deep water rice. This problem can be overcome by using elite breeding lines having improved morpho-physiological features/traits such as more chlorophyll content of leaves, better CO2 concentrating mechanism, erect and long flag leaves, tall and lodging tolerance along with robust and thicker stem base, more biomass, robust green stems with more tillers/plant, alive green leaves, stems with more chlorophyll provide more active photosynthetic duration (no senescence) up to maturity stage and vigorous roots might contribute to more water and nitrogen uptake for efficient photosynthesis. Therefore, development and release of high yielding tall DWR varieties in aman season is necessary for increasing rice yield and income of the resource poor farmers.

Description of the Technology

- BR10230-15-27-7B has been released as first high yielding tall (190 cm) DWR variety namely BRRI dhan91 with larger vascular bundle, perennial growth habit and lodging tolerance, super ratooning ability, no leaf senescence and higher photosynthetic efficiency
- BRRI dhan91 is suitable for wide ranges of area from drought prone to semi-deep flooded areas with yield potential of 4.0-4.5 t/ha and having 1.0-1.5 t/ha yield advantage over local cultivar. SUB1 gene and high yielding traits are incorporated into tall BRRI dhan91 for better adaptation in semi-deep flooded conditions (shallow flooded up to 1 meter) having submergence tolerance of 10-12 days
- Transplanting should be done on 10-15 August with 30 day old seedlings having spacing 20cm x 20cm using 1-2 seedlings/hill. Growth duration is 140-145 days. Farmers could harvest the crop 10-15 days earlier than local cultivars
- BRRI recommended fertilizer management, weeding, rouging, threshing, drying along with other intercultural operations should be used properly to ensure quality seeds and increased rice production.

Benefit of the Technology

- BR10230-15-27-7B (BRRI dhan91), BRH11-9-11-4-5B and BR10238-5-1 should be used in breeding program to increase the rice yield for breaking the yield ceiling of DWR and to ensure food security for the nation
- High quality dry straw (10-11 t/ha) of BRRI dhan91 could be used as quality cattle feed
- BRRI dhan91 with C3 plus photosynthetic pathway could be evaluated for efficient and low cost bio-fuel extraction
- Ratoon crop of BRRI dhan91 could give better yield (4.0-4.5 t/ha) as like main crop. This technique could reduce cost of seeds of farmers.

Researcher:

Dr. A. S. M. Masuduzzaman
CSO, Plant Breeding Division
BRRi, Gazipur-1701
Mobile:01735-598805; Email: masudbrri@gmail.com

Management of Insects and Diseases of Rice Under Changing Climate in Southern Region

Introduction

The incidence and severity of disease and insect pest infestation is greatly affected by weather parameters, crop sequence, alternate host, etc. In recent years, many pests and diseases have been reported to be the major limiting factors affecting rice production due to intensive cultivation practices and indiscriminate use of nitrogenous fertilizers and pesticides. There is a change in the disease and insect pest scenario in rice due to changes in climate and agro ecosystem. Moreover, use of high yielding varieties along with monoculture also influences diseases and insects, and minor of these problems have become major ones. Barishal region is an endemic area for disease and insect pest of rice especially, rice blast (Magnaporthe grisea) disease, insect pest BPH, leaf folder (Cnaphalocrocis medinalis). Those disease and insects have a long history of outbreak in Barishal region of Bangladesh. Now-a-days, false smut (Ustilaginoidea virens) is becoming a threat for rice production in late transplanted Aman rice. So, appropriate management practices need to be developed considering relationship between the weather factors and pests development at Barishal region.

Description of the Technology

- Nitrogen is the most limiting nutrient in tidal flooded soil. Urea (nitrogen-fertilizer) has positive effect on stem borer insect performance. Potassium provides high resistance against insect-pests. Phosphorus-fertilizer also decreases the host suitability to stem borer. Zinc and sulphur also reduce this pest population. Application of N and P might reduce brown spot infection while application of K, S and Zn might reduce BLB and sheath blight development
- Use of optimum dose or little bit lower dose of Urea (22 kg Urea/33 decimal land for BRRI dhan49), chemical spray (Azoxystrobin + Propiconazole) at booting stage and seeding at 30 June or 30 July minimizes false smut disease of rice in southern region of Barishal
- Four new chemicals viz. Tebuplus75, Quickout50WP, Dlink 32.5 and Mcvo 75 significantly reduce (90-94%) blast disease incidence of rice
- The need based insecticide management (NBIM) package reduces infestation
- Use of resistant/tolerant varieties against disease and insect pest is one kind of management practice. BRRI released HYVs rice such as BR23, BRRI dhan52, BRRI dhan72, BRRI dhan76, BRRI dhan58, BRRI dhan64, BRRI dhan67, BRRI dhan74 and BRRI Hybrid dhan3 are less affected by disease and insect attacks

Benefit of the Technology

- New chemicals viz. Tebuplus75, Quickout50WP, Dlink 32.5 and Mcvo 75 could be used for effective blast disease management
- By using need based insecticide management (NBIM) package farmers can save 2-3 insecticide applications which will reduce use of hazardous chemicals detrimental to environment
- Rice production could be increased in Barishal region using resistant HYV rice varieties against pest and disease infestation
- Farmers could correct the time of planting to avoid blast and false smut diseases of rice

Researcher:

Dr. M. Alamgir Hossain
Cheif Scientific Officer, BRRI Regional Satation
Sagordi, Barishal
Mobile: 01922-550400; Email:mahbrri2012@gmail.com

Quality Seed Production of BRRI Released Rice Varieties At Farmer's Level

Introduction

Rice production depends on many factors and among them suitable variety is the most important. Many farmers in southern and central regions are still using the traditional varieties or old BRRI released varieties which are now susceptible to different diseases. The newly released varieties can replace the local and old varieties which will significantly increase the rice production and improve farmers' income and livelihood. BRRI has recently developed BRRI dhan70, 71 and 75 suitable for central region where cropping intensity is higher and BRRI dhan76 and 77 suitable for tidal submergence non-saline Barishal region in T. Aman season. Farmers in Barishal region generally grow long duration (150-170 days) local cultivars like Shadamota, Lalmota, Dudkalam etc especially for very tall seedlings at the time of transplanting but yield is low (around 3-3.5 t/ha). BRRI dhan76 and 77 are able to replace those local cultivars with yield advantage of around 1.5 t/ha, produce very tall seedlings similar to that of local cultivars but growth duration is about 7-15 days earlier than the locals. For irrigated Boro season, BRRI developed some promising varieties like BRRI dhan58, 60 and 63. These promising Aman and Boro varieties need to reach the farmers' vicinity rapidly by up-scaling programs which will significantly increase the rice production. So, there is a wide scope to increase rice production by rapid introduction of the newly released BRRI varieties to the southern and central regions of the country. Dissemination of these varieties could be done by enhancing the availability of quality seeds at farmers' level.

Description of the Technology

- BRRI released newly rice varieties BRRI dhan70, 71 and 75 are suitable for central region while BRRI dhan76 and 77 are suitable for tidal submergence non-saline Barishal region in T. Aman season
- In T. Aman season, seedling age for BRRI dhan70, 71 and 75 should be 25-30 days and those for BRRI dhan76 and 77 should be 35-45 days and in Boro season, seedling age for BRRI dhan58, 60 and 63 should be 40-45 days depending on locations
- In irrigated Boro season, BRRI dhan58, 60 and 63 should be used in central region which would significantly increase the rice production
- Detailed varietal characteristics of all the BRRI released high yielding rice varieties are available in different BRRI publications
- BRRI recommended fertilizer management, weeding, rouging, threshing and drying should be performed properly to ensure quality seeds
- Plastic drums (Each capacity of 75-80 kg paddy) should be used for retaining seeds by the farmers

Benefit of the Technology

- The short duration rice varieties would facilitate to grow rabi crops after T. Aman harvest
- Farmers of the central region will be benefitted by using the newly released varieties as the growth duration of BRRI dhan58 and 60 ranged from 141 to 146 days which are shorter than the mega variety BRRI dhan29 (160-170 days) having almost similar yield
- The yield advantage of the developed varieties for Barishal region is around 1.5 t/ha, produce very tall seedlings similar to that of local cultivars but growth duration is about 7-15 days earlier than the local varieties
- Farmers' income and livelihood will be increased significantly through adoption of new promising rice varieties

Researcher:

Dr. Md. Shafiqul Islam Mamin
Cheif Scientific Officer, ARD, BRRI, Gazipur-1701
Mobile: 01711-075486; Email: msimamin@yahoo.com

Ginger Production under Soil less Culture using Fertigation Technique

Introduction

Ginger is one of the important major spices crop grown in Bangladesh which possesses favorable agro-ecological condition for the production of ginger. The yield of ginger in Bangladesh is very low compared to other countries. The lowest production of ginger is due to lack of suitable land for cultivating high quality and severe attack of rhizome rot causing lack of interest among the farmers to cultivate ginger. Rhizome rot is a complex disease caused by bacteria, fungus and nematode. Among the several factors affecting ginger production, the rhizome rot caused by Pythium aphanidermatum is responsible for drastic yield reduction which is difficult to control through single approach. Not only Pythium aphanidermatum is but also some other fungi and bacteria might be associated for rhizome rot of ginger. The pathogen causing rot is soil borne and as well as seed borne. The disease may reduce 50 -80% rhizome production.

Description of the Technology

- Fertigation technology is normally applied in soilless culture. Soilless culture system produce disease free seed rhizome as well as reduced the infection. In this system, seed rhizomes are planted in soilless substrate (such as coco-dust, saw-dust, paddy husk) placed in black poly bag using fertigation technique;
- The fertigation method using coco peat in black plastic bag is an alternative technique in ginger cultivation to overcome the problem for ginger cultivation effectively and efficiently. In fertigation system, irrigation and fertilization are done simultaneously and directly to the root zones at a required amount;
- Ginger cultivation in soilless substrate such as (i) coco-dust, (ii) saw dust, (iii) rice bran, (iv) 50% coco-dust + 50% saw-dust, (v) 50% saw-dust + 50% rice bran, (vi) 50% Coco-dust + 50% rice bran in poly bags (sizes are 40 cm x 30 cm x 30 cm) using fertigation technique can overcome the disease problem (bacteria and fungi) to some extent and increase the productivity of ginger;
- Three suitable ginger varieties are (a) BARI Ada-1, (b) BARI Ada-2 and (c) BARI Ada-3;
- The best time for Rhizome planting is April and the harvesting time is generally February. Spacing of poly bags are 12-15 cm which filled with the substrate and are to be kept in shady place for 15 days before planting;
- Each poly bag need to be individually irrigated with nutrient solution via a dripper on the surface of the growth media placed in poly bag. Intercultural operations are not needed;
- Suitable areas for ginger production are all over Bangladesh.

Benefit of the Technology

- The higher yield of ginger in fertigation system (45.2 tha^{-1}) could be obtained using coco-dust with the variety BARI Ada-1 than the conventional method (14.24 tha^{-1}) and by following this system, the farmers will be able to earn TK. 26,21,534.00 per. ha against Tk. 6,32,894.00 in conventional method;
- The benefit cost ratio is 2.40 may be obtained from plants of BARI Ada -1 grown in Cocodust media using fertigation technique;
- This production system of soilless culture using fertigation technology is useful for production of quality rhizomes (seeds) of ginger; and
- Soilless culture using fertigation technology is more environments friendly.

Researcher:

Dr. Md. Ashikul Islam
Senior Scientific Officer
Spices Research Centre, BARI
Shibganj, Bogra
Mobile: 01711119287, Email: nirusrc@yahoo.com

Maize Based Cropping Patterns for Sustaining Soil Fertility and Enhancing Income

Introduction

Maize is the third most important cereal crops after rice and wheat which plays a significant role in human and livestock nutrition worldwide. Recent expansion of the maize area under rice-maize system is very rapid in Bangladesh. Diversification to maize could also be a good strategy for climate change adaptation. Soil nitrogen as well as organic matter could be replenished by growing legumes after maize. Planting short duration rice varieties would allow farmers to plant maize earlier and therefore, to fulfill the demand, maize based cropping systems would be developed with improved and sustained soil fertility.

Description of the Technology

- Improved maize based cropping patterns: (i) Maize (981) – Mung bean(BARI Mung-6) -T.aman (BRRIdhan 49, 57); (ii) Maize-Mungbean-T.aus (BRRIdhan 48) and (iii) Maize – Black gram (BARI Mash-3) -T. aus are recommended over the existing cropping pattern Maize - Fallow - T. aman in the major maize growing areas of South Western region of Bangladesh(Jhenaidah, Chuadanga and Meherpur districts) for increasing production per unit area and time as well as to sustain soil fertility
- The farmers usually sow the seeds of Maize in line with 60 cm row to row and 20 cm seed to seed in November and harvesting time is in April. The Mungbean and Blackgram are generally sown in April. Twenty five to thirty days aged seedlings of T. aus and T. aman are transplanted from June to July;
- The fertilizer doses for Maize are 70-26-45-7 NPKS hectare^{-1} and for T. aman rice requires 75-45-35-10 NPKS hectare^{-1} from urea, TSP, MoP and Gypsum. Intercultural operations are taken against insects and diseases as and when necessary
- Suitable areas of these cropping patterns would be the Upazillas of Jhenidah and Chuadanga districts namely, Jhenidah Sadar, Kaliganj, Jibonnagar and Damurhuda (South Western region of Bangladesh).

Benefit of the Technology

- The highest grain yield of maize (11.27 tha^{-1}) would be obtained from Maize - Mungbean -T.aman cropping pattern which ranges from 10.89 tha^{-1} to 11.27 tha^{-1}. However, Mungbean and Blackgram could produce grain yield ranging from 0.95 to 1.02 tha^{-1}, and green biomass and dry stover yield ranges from 9.40 to 10.63 tha^{-1} and 1.63 to 1.89 tha^{-1}, respectively;
- Inclusion of a pulse crop in the cropping pattern during fallow period would reduce the requirement of chemical fertilizers in the next crop maintaining a good health of soils through biological nitrogen fixation and addition of organic matter to soil
- The highest amount of nitrogen and potassium recycles from mungbean / blackgram biomass ranges from 67.76 to 72.38 kg ha^{-1} and 42.24 to 45.12 kg ha^{-1} and farmers' income is increased 15-24% by adopting pulse crop in the improved Maize - Mungbean -T. aman / T.aus cropping pattern. Soil nutrient mining is minimized by growing Mungbean/ Blackgram in Maize- Fallow- T.aman cropping pattern;
- The highest gross return and gross benefit could be obtained from Maize - Mungbean - T. aman cropping pattern which is 26% higher against Maize - Fallow - T. aman cropping pattern.

Researcher:

Dr. Md. Sirajul Islam
Chief Scientific Officer
Bangladesh Agricultural Research Institute
Mobile. 0171-2142042, Email: sirajpso1960@yahoo.com

Management of Acid Soils for Sustainable Crop Production

Introduction

Land degradation is a major threat to food production & environmental security. Acid soil is an important problem soil in Bangladesh because of its adverse effect on soil fertility and crop productivity. Acid soils possess higher concentrations of Al^{3+}, Fe^{3+} and Mn^{2+}, lower concentrations of P and low availability of bases as result decrease pH level below 6.5 which together cause reduction in crop yield. The area of agricultural land in Bangladesh with acid soils is approximately 6.5 million hectare. Acid soils may constraint crop production in more than 30 % of lands of Bangladesh

Liming is a well-known approach for correcting acid soil along with restoring Ca availability and alleviating Al, Fe and Mn toxicity in plants. Regular application of well decomposed organic matter in acid soils is useful to prevent sudden fluctuation of soil pH as it improves the buffer capacity of soils.

Description of the Technology

- Application of lime @ 1 tha^{-1} to 2 tha^{-1} (depend on pH level) can increase the grain and straw yields of crops for the below recommended three cropping patterns
- The Suitable Cropping patterns are (i) T. aman rice (BRRI dhan-71 / BINA dhan7) – Wheat (BARI Gom 30)-Mungbean (BARI Mung- 6), (ii) T. aman rice-Maize (BARI Hybrid Maize-9) - Fallow and (iii) T. aman rice – Mustard (BARI Sarisha-14) - Boro (BRRI dhan28) for Northern and Eastern Piedmont Plains (AEZ 22) and Madhupur Tract (AEZ 28) in acid prone areas of Bangladesh
- The recommended doses of N, P, K, S, Zn and B for all crops are according to FRG-2012 (BARC). The suitable dose for T. Aman rice is $N_{90}P_{10}K_{35}S_8B_1$ kg ha^{-1}, Wheat is $N_{120}P_{30}K_{605}S_{10}$ Zn1.3B.6 kg ha^{-1}) - Maize is N_{255}P75$K_{80}S_{36}Zn_{10}B_1$ kg ha^{-1} kg ha^{-1} and Mustard is with $N_{90}P_{27}K_{32}S_{15}Zn_1B_1$ kg ha^{-1} and Boro rice is having $N_{150}P_{20}K_{66}S_{18}Zn_{1.3}$ kg ha^{-1}. Sources and rate of lime and organic matter should be dolomite @ 1 tha^{-1} to @ 2 tha^{-1} , cow dung @ 5 $tha^{-1}$and poultry manure @ 3 t ha^{-1} respectively
- Seedlings of T. aman and Boro rice should be transplanted in July- August and February respectively. While seeds of wheat, maize and mustard need to be sown in November 15=30, July –August and November respectively. All the crops should be harvested at appropriate maturity
- Liming is suitable for areas of (i) Acid soils of Old Himalayan Piedmont Plain (AEZ 1), (ii) Lower Purnabhaba Flodplain (AEZ 6), (iii) Ganges Tidal Floodplains containing acid sulphate soils (AEZ 13), (iv) Gopalganj - Khulna Bils containing peat soils (AEZ 14), v) Arial Bil (AEZ 15), (vi) Sylhet Basin (AEZ 21), (vii) Northern and Eastern Piedmont Plains (AEZ 22), (viii) Chittagong Coastal Plains having acid sulphate soils (AEZ 23), (ix) Level Barind Tract (AEZ 25), (x) North Eastern Barind Tract (AEZ 27), xi) Madhupur Tract (AEZ 28), and (xii) Northern and Eastern Hills (AEZ 29).

Benefit of the Technology

- Application of lime and organic manure to acid soils is beneficial for plant to uptake available forms of nutrients and finally achieving sustainable crop productivity in acid prone areas of Northern and Eastern Piedmont Plains (AEZ 22) and Modhupur Tract (AEZ 28)
- Many upland crops such as maize, mustard, wheat, pulse, etc. could be grown well through management of acid soils by applying lime or combination of lime and organic matter in Madhupur Tract and Northern & Eastern Piedmont Plains
- The yields of wheat (35%) and maize (38%) could be increased due to application of minimum 1.0 – 2.0 tha^{-1} lime over no lime application.

Researcher:

Dr. Md. Anamul Hoque
Professor, Department of Soil Science
Bangladesh Agricultural University, Mymensingh-2200
Mobile: 01741-390715, Email: anamul71@yahoo.com

Fertilization for Rooftop Gardening

Introduction

Rooftop gardening is going to be popular in urban areas of Bangladesh. Due to the urbanization, cultivable lands are decreasing day by day. As there is limited scope for horizontal expansion of agriculture, vertical expansion is one of the major ways to increase crop productivity. Rooftop gardening is one of the potential areas for vertical expansion. As it was estimated that, there are about 2 lac house hold in Dhaka city from where rooftop can be used for this purpose. A rooftop garden not only could be a source of agricultural production but also could be able to fix CO2 and some other gases causing greenhouse effect. So, there are many scopes for rooftop gardening for producing different types of vegetables on rooftop but research information on nutrient management for rooftop garden is not available. There is possibility to increase the yield of different types of vegetables, fruits and flowers on the rooftop but most of the rooftop gardeners do not know the appropriate nutrient management packages for growing crops in rooftop garden.

Description of the Technology

- Application of 80% fertilizer of Soil Test Based (STB) doses along with 2 kg vermicompost for 6 kg soil is recommended for maximizing the yield of different vegetables, fruits and flowers grown on the rooftop enhancing crop productivity;
- In case of soil and organic fertilizer combination, application of 1 kg vermicompost for 1 kg soil is recommended for enhancing the yield of vegetables (capsicum & bottle gourd), fruits (strawberry) and flowers (periwinkle, gladiolus and gerbera) grown on the rooftop garden. Wooden box (1mx1m), half drum (contain 75 kg soil) and pot (15 kg soil) may be used for producing vegetables, fruits and flowers on rooftop garden
- Different vegetables namely Red Amaranth (BARI Lalshak-1), Amaranth (BARI Danta-2), Spinach (BARI Palongshak-1), Ind ian Spinach (BARI Puishak-2), Kangkong (BARI Gimakolmi-1), Batishak (BARI Batishak-1), Chinashak (BARI Chinashak-1), Bt. Brinjal (BARI Bt. Brinjal-2), Tomato (BARI Tomato-15), and Chilli (Baromashi); fruit (Lemon, Seedless); and flowers (Tuberose, Single), Marigold (Inca) and Rose (Hybrid) could easily be grown on rooftop garden having chemical fertilizer based on initial soil test value following the BARC Fertilizer Recommendation Guide, 2018; and
- Suitable areas are the rooftop in urban areas of Bangladesh.

Benefit of the Technology

- Crop yields could be increased by 30 to 400% (vary crop to crop) in the rooftop garden
- The developed technology will help to increase crop production as well as income.

Researcher:

Ibne Saleh Md. Farhad
Scientific Officer
Soil Science Division
Bangladesh Agricultural Research Institute
Mobile: 0171-7476320
Email: farhadsau@gmail.com

Crop Yield Enhancement in Saline Soil using Polythene Mulch and Potassium Fertilization

Introduction

Soil and water salinity restricts the expansion of Rabi/Kharif-I crop growing areas in the saline soils of Bangladesh. Uncertain rainfall in September-November due to climate effect also make difficult to grow T. aman rice. Despite salinity exerts lethal effect, it is necessary to increase quality food production like high value vine crops e.g. bitter gourd, snake gourd, sweet gourd, water melon, melon etc. to feed the ever increasing population. Appropriate technology is therefore, needed to compensate the crop losses occurred by salinity. Therefore, the introduction of high value vine crops in the cropping system through reduction of salinity effect by judicious use of polythene mulch and optimum rate of K fertilizer application would improve crop productivity in coastal saline soils of Bangladesh.

Description of the Technology

- The seeds/seedlings could be sown / transplanted in soil using a hole where irrigation water is supplied at the foot of each plant once or twice a week through the round cut hole of the polythene sheet. Application of water keeps frequently in the rhizospheric area for salt removing;
- The seeds/seedlings could be sown / transplanted in pits maintaining 2m ×2m spacing. In polythene mulch system, the pit soils are to be covered with a one and half meter diameter polythene sheet. The seeds/seedlings are then to be sown/transplanted in soil within the 5 cm diameter round-cut portion in the central point of the polythene sheet. Rice straw also would be used as mulching.
- Every plant should received the recommended rate of fertilizers following the BARC Fertilizer Recommendation Guide, 2018 based on initial soil test value except K fertilizer. Triple Super Phosphate (TSP), Gypsum, Boron and Zinc are to be applied in pit at final land preparation while Urea would be applied with irrigation water in three equal splits
- K fertilizer (MoP) would be applied during final land preparation. It is suggested that split application is found suitable than the sole basal application of K; and
- Vine crops [bitter gourd (Lalteer Hybrid Tiya), snake gourd (Lalteer Hybrid Chichinga Padma), sweet gourd (Lalteer Hybrid), water melon (Takii seed Big Family) and melon (Chinese Bangi)] to be grown in pits of saline soils by maintaining appropriate spacing as well as the yield of these crops could be improved by using polythene mulch and potassium fertilizer (varying 100 - 150 kg ha^{-1}) in coastal saline soils of Bangladesh.

Benefit of the Technology

- Potassium application @ 100% recommendation is good enough to obtain better yield of vine crops like bitter gourd (20 -25 tha^{-1}), snake gourd (20-27 tha^{-1}), water melon, melon and sweet gourd each yielded 30 tha^{-1} having polythene mulch cover of the above crops in Rabi season. However, T. aman rice (BRRIdhan 73) responses well in coastal region of Bangladesh to get optimum yield (4.7 tha^{-1});
- By adopting polythene mulch technology, the salt affected fallow lands could be brought under crop cultivation. This would increase the production of vegetables several folds which will ensure the vegetable security of the coastal people;
- Reduces evaporation loss of water from the soil surface through Polythene mulch;
- Keeps the soil moist for longer time after irrigation and requires very less amount of water;
- Protects land from salinization by reducing evaporation losses of water from soil;
- Keeps root zone area salt free and assists in weed control
- Accelerates crop development in cool climates by increasing soil temperature;

Researcher:

Dr. Asadul Haque
Professor, Department of Soil Science
Patuakhali Science and Technology University
Dumki, Patuakhali
Mobile: 0171-5066089
Email: masadullh@yahoo.com

Exploitation of Kitchen Waste for Vermicompost Production and Utilization

Introduction

Cabbage and tomato are popular winter crops in Bangladesh. Both of them are nutritious vegetables containing appreciable amount of vitamin A, B, C and calcium. Cabbage and tomato are exhaustive crops uptaking huge amount of nutrients from soil. The farmers are mainly applying inorganic fertilizer to replenish this huge amount of nutrients. Application of organic manure like vermicompost could be an increase of their yield, taste and quality. Vermicomposting is gaining popularity in Bangladesh as the technology is simple, viable and cost effective. Vermicomost contains 1.32% N, 0.94% P, 0.76% K and 0.36% S. Cabbage and tomato cultivation is popular in many areas of Bangladesh. Judicious application of vermicompost with chemical fertilizer for production of cabbage and tomato are rare. Therefore, there is a possibility to increase the yield of cabbage and tomato through integrated use of vermicompost and chemical fertilizer.

Description of the Technology

- The high quality of vermicomposting substrate is produced from 75% cow dung + 25% cabbage leaf. About 80% (weight basis) of household solid waste is organic in nature which can be converted to compost, vermicompost and trichocompost. The efficient earth worm species capable to produce vermicomposting are Eisenia fetida, Eudrilus eugeniae and Perionyx excavat;
- Three organic manure (compost, vermicompost and trichcompost) at three level (1.5, 3.0 and 6.0 tha^{-1}) along with three levels of recommended chemical fertilizer (100, 80 and 60 percent) are to be applied for production of cabbage and tomato;
- The whole amounts of vermicompost, TSP, MoP, gypsum, zinc sulphate, boric acid and 1/3rd of urea would be applied at the time of final land preparation. The remaining 2/3rd of urea is to be applied as a top dress in two equal splits at vegetative growth stage (30-35 days after transplanting), and head formation stage of cabbage (55-60 days after transplanting) or fruiting stage for tomato (55-60 days after transplanting);
- The suitable cabbage variety Atlas-70 requires fertilizers (urea-340, TSP-250, MoP-160, gypsum-100, zinc sulphate-6 and boric acid-5 kg ha^{-1};)for the Central region and Green King (urea-350, TSP-275, MoP-220, gypsum-125, zinc sulphate-6 and boric acid-5 kg ha^{-1}) at Northern region of the country and for tomato (variety is BARI Tomato-15; needsurea-350, TSP-300, MoP-210, gypsum-125, zinc sulphate-9 and boric acid-5 kg ha^{-1}) for both the locations;
- Seedling age for both crops are 30 days and transplanting time of cabbage and tomato are 2nd week November and harvesting time for Cabbage is 1st week February and for Tomato is 2nd week of February to 3rd week of March. The row to row distance is 50 cm for cabbage and 60 cm for tomato and plant to plant distance of both the crop is 40 cm. This technology is suitable for AEZ-28 (Madupur Tract) and AEZ-3 (Tista Meander Floodplain soil);

Benefit of the Technology

- Integration of 1.5 ton vermicompost ha^{-1} with 100% recommended dose of chemical fertilizer are recommended for maximizing the highest yield of cabbage (65-75 tha^{-1}) and tomato (70-75 tha^{-1}). Cabbage and tomato yield could be increased by 20-25% by applying 1.5 t vermicompost ha^{-1} with 100% recommended chemical fertilizer;
- Using both organic and inorganic fertilizer, the farmers would be benefitted. Highest marginal cost benefit ratio for Cabbage (7.10) and Tomato (9.88) are achieved both from the treatment where 100 % RCF + 1.5 t/ha Vermicompost are used and Soil health will be improved substantially.

Researcher:

Dr. Ranjit Sen
Senior Scientific Officer
Soil Science Division
Bangladesh Agricultural Research Institute
Jaydebpur, Gazipur-1701
Mobile: 0172-6261815, Email: senranjitbd@yahoo.com

Vermicompost and Organic Manure: Improvement of Soil Fertility and Crop Productivity

Introduction

Vermicomposting is a simple biological process of composting in which certain species of earthworms are used to enhance the process of waste conversion into a better end product. The process is faster than conventional composting; because the material passes through the earthworms gut. The resulting earthworm castings (worm manure) are rich in plant nutrients and narrow in C:N ratio. Vermicompost provides all nutrients in readily available form which is well synchronized for nutrients demand of the crops than conventional compost. In this country, vermicomposting is mainly based on cow dung and low in plant nutrients. Now- a- days, cow dung is less available for vermicomposting due to inadequate production and multi-purpose utilization. Therefore, development of a Plant Nutrient Rich Vermicompost with the mixture of soil, cow dung, is urgently required for improving soil fertility and crop productivity.

Description of the Technology

- Mixtures of soil, cow dung (CD), rice straw (RS), poultry manure (PM) and giant mimosa residue (GMR) at the ratio of 2:1.33:1.33 and 1.33 respectively with red wigglers earthworms are suitable for the production of quality and nutrient rich vermicompost
- Red wigglers earthworms (Eugenia fetida) are more effective than mixture of local earthworms (Perrionix excavates, Lumbricus rubellus, Eudrilus eugeniac etc.). Red wigglers can decompose faster of the different organic materials and made the vermicompost greater stable than the mixtures of local earth worms
- About 75% CF (NPKS) with 4 tha^{-1} vermicompost or 85% CF (NPKS) with 2 tha^{-1} vermicompost are almost equally effective to the full dose (100%) of CF (Urea, TSP, MoP and gypsum) to produce seed yield of mustard and grain yield of Boro rice and about 75% CF (NPKS) with 2 tha^{-1} vermicompost is equally effective to full dose (100%) of CF for T. aman rice cultivation
- Vermicompost is to be applied during the final land preparation for every crop.

Benefit of the Technology

- Based on results, 75% chemical fertilizer (CF) with 4 tha^{-1} vermicompost or 85% CF with 2 tha^{-1} vermicompost almost equally effective to the full dose (100%) of CF to produce seed yield (1.4 tha^{-1}) of mustard (Binasharisha 10, having 85% CF + vermicompost @4 t ha^{-1}) and grain yield of Boro (BINA dhan 14 having having 100% CF + vermicompost @ 4 tha^{-1}) rice (6.4 tha^{-1}). In T. aman rice (6.02 tha^{-1} having 85% CF + vermicompost @ 2 tha^{-1}), 75% chemical fertilizer (CF) with 2 tha^{-1} vermicompost is equally effective to full dose (100%) of CF
- About 15-25% chemical fertilizer (NPKS) could be saved either with the application of 75% CF with 4 tha^{-1} vermicompost or 85% CF with 2 tha^{-1} vermicompost for Mustard-Boro rice-T. aman cropping sequence
- Soil fertility (organic carbon, total N, available P, exchangeable K and available S) would be slightly increased with the application of vermicompost in the Mustard-Boro rice-T. aman cropping pattern
- The production technology is easy and environment friendly.

Researcher:

Dr. Md. Azizul Haque
Principal Scientific Officer
Soil Science Division
Bangladesh Institute of Nuclear Agriculture
Mymenshingh
Mobile: 0171-6627303, Email: azizul_bina@yahoo.com

BTRI Tea Clones For Enhancing Quality Seed Production

Introduction

The cultivation of tea in Bangladesh has concurrently developed with North-East India. But the production of tea is less than that of India. The important reason of such low production is assumed to be due to the inferior stock of genetic materials. Bangladesh Tea Research Institute (BTRI) so far released 21 outstanding quality clones and five seed stocks. But till to date, hardly 6-9% clonal plantations is covered in tea gardens of Bangladesh. Clones selected from the indigenous plant population and tested under prevailing climatic and soil condition are more suitable and adaptive to respond for better crop production, pest and disease resistance in the long run. At present, there are about 17 thousand hectares new tea areas need to be replanted (7678 hectares for extension, 535 hectares for small holdings and 8651 hectares for very old tea area). As a matter of policy 50% of the area should be planted with improved clones and 50% with improved seedlings having approved or proven clones suited to our environment. But the industry requires 2.4 crore saplings to plant 17 thousand hectare clonal plantation in the same period. Thus, BTRI can fulfil only 6.67% of the total need. Rest 93.33% i.e. 2.24 crore clonal plants has to be raised by gardeners' own resources and private sector nurseries. Sufficient planting materials need to be raised in quickest time to meet up the need of the industry.

Description of the Technology

- The Nucleus Clone Plot (NCP) and biclonal seedbarie (tea seed orchard) are to be established in each tea garden. The clonal saplings of 60 cm height of ten improved BTRI tea clones such as BT2, BT4, BT5, BT6, BT9, BT12, BT13, BT14, BT16 and BT17 are to be used for establishing Nucleus Clone Plot (NCP) in a block. The size of each block can be 6m × 6m having 1.2m × 1.2m planting spacing with 25 plants per block
- Biclonal seebarie (Tea Seed Orchard): The seedbarie of BTS1 and BTS2 seed stock are to be developed. BTS1 consists of BT1 and TV1 clones with the ratio of 3:1 and BTS2 comprises of B207/39 and TV1 clones with the ratio of 1:1. The spacing of plants is 4m × 4m and 5m × 5m for tillah and flat, respectively.

Benefit of the Technology

- Using ten improved BTRI tea clones of BT2, BT4, BT5, BT6, BT9, BT12, BT13, BT14,BT16 and BT17 having 3000 to 3500 kg/ha yields with above average cup quality can increase tea production substantially in the country
- Similarly, using two seedbarie having the yield performance of those progeny ranging 3500 to 4000 kg/ha with above average cup quality can improve the tea production remarkably in the country.

Researcher:

Dr. Md. Abdul Aziz
Botany Division, BTRI
Srimangal, Moulvibazar
Mobile: 01718-280981; Email: aabtri@gmail.com

Tomatillo: A Unique Introduction as New Crop

Introduction

Tomatillo (*Physalis philadelphica* Lam./*Physalis ixocarpa Brot.*) is originated in Mexico but a new crop in Bangladesh. Tomatillo belongs to the family Solanaceae bearing round shaped and green or purple coloured fruit. The tomatillo fruit is surrounded by an inedible, paper-like husk formed from the calyx. From outside it is similar as a common weed of our country "Foshka Begun". At maturity, it fills the husk and can split it open by harvest. Inside the husk, green tomatillo fruit looks same as green tomato but inside the fruit it is compact fleshy, firm and bright green. The "SAU tomatillo 1" and "SAU tomatillo 2" are two developed varieties can be grown in optimum, drought and saline environments. Now it is the time to spread the cultivation of these two varieties to different regions of Bangladesh. So introduction of new species and variability among them could contribute to the crop diversity as well as food security enhancement.

Description of the Technology

- Tomatillo is a new crop species is recommended for cultivation in optimum, drought and saline environments for crop diversification
- The date of sowing is early to mid-October and seeds to be sown in seedbed with rows spaced at 10 cm apart to raise seedlings. Seedlings are to be raised using usual nursery practices with regular irrigation
- Twenty five days old seedlings are to be transplanted using at least two seedlings/hill in the main field with spacing 40 cm x 40 cm. Fertilizers and farm yard manures could be applied only during land preparation at the rate of cow dung 10 ton/ ha, Urea 550 Kg/ha, TSP 450 Kg/ha and M0P 250 Kg/ha
- Mechanical supports could be provided to the growing plants by bamboo sticks to keep them erect. Necessary intercultural operations should be applied as and when required
- Harvesting will be continued for long time because fruits are mature progressively at different dates over long time
- Seeds could be collected and stored at 4°C for future use.

Benefit of the Technology

- Tomatillo is a high yielding (2.5 kg/plant), short duration (Growth duration- 85-90 days and date of 50% flowering-58 days) and eco-friendly crop as there is no need of pesticide spray
- Tomatillo has good nutritional and medicinal values having anti-cancer, anti-cardiovascular and anti-bacterial properties
- Both of SAU tomatillo 1 and SAU tomatillo 2 can be grown under slight to moderate, drought and salinity stress conditions
- Yield loss is minimum due to bird attack during maturity

Researcher:

Dr. Naheed Zeba
Professor, Department of Genetics & Plant Breeding
Sher-e-Bangla Agricultural University, Dhaka
Mobile: 01913-091772; Email: naheed0359@yahoo.com

Cotton Production in the Drought Prone Barind Tract

Introduction

The north western Barind Tract, an unfavorable agro-ecosystem, though not suitable for many crops but is a potential area for expansion of cotton cultivation because of its stress tolerant characters. The performance of cotton CB-14 variety is satisfactory in the favorable agro-ecosystem of Bangladesh. The vulnerability of cotton plant depends on the growth stage expose to drought adjusting the sowing time by which drought sensitive growth stages can be avoided. The Barind Tract suffers from frequent drought situation due to irregular rainfall which could be overcome by conserving the available rainwater and soil moisture in the cotton field by adjusting sowing date and mulching cover on cotton field which influences yield and fiber quality in the Barind Tract.

Description of the Technology

- Cotton variety CB-14 is recommended for cultivation in the drought prone areas of Barind Tract of Natore, Rajshahi, Naogaon, Dinajpur, Joypurhat and Rangpur districts for increasing the production of cotton
- Seeds of cotton CB-14 together with straw mulch need to be sown between 10 to 25 July at Barind Tract for maximizing seed cotton yield but not to be sown after 10 August because of conserving higher soil moisture during this stipulated time. Mulching should be done in between two rows of cotton. Mulching has the capability to reduce the yield gap in the Barind Tract in case of delay sowing
- Urea, TSP, MoP, Gypsum, Borax, Zinc Sulphate, Magnesium Sulphate and vermicompost need to be applied @ 240, 265, 300, 150, 22.5, 22.5, 22.5 and 500 kg per hectare, respectively. All the fertilizers except urea should be applied as basal and urea need to be applied in four splits after 22, 45, 60 and 80 days of seed sowing
- Intercultural operations as well as spraying of insecticides and fungicides need to be done as and when necessary. However, first spray of chloropyriphose to be applied against sucking pests such as Jassid and Aphid etc after 26 days of seed sowing. Other five sprays are to be applied with chloropyriphose in combination with pyrithroid to control sucking and chewing (boll worms) pests. Attack of spodoptera could to be controlled by using pheromone trap. Hand picking, pheromone trap and bird trap may also be used to kill moths and adults of the insects.

Benefit of the Technology

- Higher seed cotton yield (3.23-3.30 t/ ha) could be obtained by following optimum seed sowing time (10-25 July) together with straw mulch practices in the drought prone areas of Barind Tract.
- Higher Benefit Cost Ratio (1.08) could be obtained from the optimum seed sowing time (10 -25 July) together with straw mulch than the late seed sowing time after 25 July (0.95) in the drought prone areas of Barind Tract.

Researcher:

Md. Rezaul Amin
Principal Scientific Officer
Cotton Research Centre
Cotton Development Board, Rangpur
Mobile: 01718-340980, Email: mramin1958@gmail.com

Eco-Friendly Technology for Promoting Vegetables/Tomato Production on Rooftop

Introduction

Urban agriculture is gaining recognition as alternative source of food and nutrition for city dwellers. Different models of urban agriculture such as vertical farming, community garden and rooftop garden have been developed and are being practiced throughout the world. But, rooftop gardening in the form of urban agriculture in Bangladesh has been practiced in small scale due of lack of technical knowledge on the use of appropriate plant growing structures and soil media, unavailability of model rooftop garden, deficiency of sufficient training and monitoring supports for the development of sustainable urban agriculture as rooftop gardening. The use of suitable plant growing structures and soil media are the effective techniques for increasing the yield of various vegetable crops in the rooftop garden.

Description of the Technology

- Concrete (plastic and earthen pot and their size would be 1.32' in diameter and 1.25' in height) and wooden bed (same as concrete bed) could be used for growing different winter vegetables /tomato in rooftop garden
- Media or mixtures of soil, cow dung and vermicompost @ 80% (w/w), 10% (w/w) and 10% (w/w) should be used in bed for transplanting seedlings of winter vegetables like BARI Tomato- 14 in rooftop gardening
- The inorganic fertilizers are to be mixed in plant growing soil medium according to Fertilizer Recommendation Guide, 2018
- The soil media should be treated with furadan to reduce the infection of soil borne diseases in crop plants. The plant growing structures would be filled with growing media
- Healthy seedlings of winter vegetables like BARI Tomato- 14 need to be transplanted in beds at afternoon at appropriate time. After transplanting, proper watering and shading need to be provided for three days to protect the seedlings from the direct sun
- Intercultural operations such as irrigation, weeding, staking and top dressing as well as spraying of insecticides and fungicides are to be done as and when required
- Suitable areas are the rooftop of city areas.

Benefit of the Technology

- Safe vegetable / tomato production as well as nutrition would be enhanced
- Higher yield of vegetables/ tomato could be obtained;
- Roof garden micro - climate could be improved by decreasing urban heat generation(reduces roof surface temperature more than 9^0C)

Researcher:

Dr. Mohammad Mahbub Islam
Professor, Department of Agricultural Botany
Sher-e-Bangla Agricultural University, Dhaka
Mobile: 01745-856611, Email: mahbubislam_sau@yahoo.com

Enhancing Crop Productivity in Saline Area through Climate Smart Technologies

Introduction

Agricultural productivity in the coastal area of Bangladesh is very low due to unfavorable conditions, which include prolonged submergence/ water logging during and after the monsoon and increasing soil salinity and lack of fresh irrigation water during the dry season. Thus, the levels of cropping intensity, crop diversity and crop yield in the area are much lower than the other parts of the country. The situation is getting aggravated due to climate change. Therefore, it is necessary to increase the crop productivity in the coastal areas by adopting climate smart technologies (Improved crop species / varieties, furrow transplanting, mulching and gypsum fertilizer) for ameliorating the stress effects.

Description of the Technology

- Improved crop varieties like (a) T. aman rice (BR11, BRRI dhan52), (b) Boro rice (BRRI dhan28 and Binadhan 10), (c) Sunflower (BRAC Hysun-33 and BARI Surjamukhi-2), (d) Maize (NK-40 and BARI Hybridbhutta-9) could be incorporated in the existing cropping pattern Fallow - T. aman rice - chilli/ bean/ groundnut/ boro rice under the saline areas for increasing the production and productivity
- Irrespective of variety, application of gypsum fertilizer @ 150 kg ha^{-1} is recommended for T. aman and boro rice to increase productivity
- Furrow transplanting along with the application of gypsum fertilizer @ 150 kg ha^{-1} is recommended for increasing the yield of boro rice (Binadhan 10 and BRRI dhan28)
- Gypsum fertilizer (100 kg ha^{-1}) along with the application of mulching (water hyacinth) is recommended for increasing the yield of sunflower (BRAC Hysun-33) and maize (NK - 40)
- Thirty days old seedling of T. aman (BR11 & BIRRIdhan52) and Boro rice (BRRI dhan28 and Binadhan 10) should be transplanted in the 1st week of August and middle of January, respectively while harvesting of these crops could be done at the1st week of November and at the end of May, respectively
- Seed sowing of maize and sunflower should be done in the last week of December and harvesting of the said crops could be done at the end of April and May, respectively
- Manures and fertilizers should be applied as per Fertilizer Recommendation Guide, 2018
- All intercultural operations including insecticides and fungicides as well as thinning and wedding are to be done as and when necessary
- Suitable areas would be the saline areas of Bangladesh.

Benefit of the Technology

- Higher yield (5.2 - 5.4 tha^{-1}) of T. aman rice (BR11, BRRI dhan 52) could be obtained with the application of gypsum fertilizer @ 150 kg ha^{-1}
- Higher yield (5.5 - 6.6 tha^{-1}) of Boro rice (Binadhan-10)could be obtained through furrow transplanting with the application of gypsum fertilizer @ 150 kg ha^{-1}
- Higher yield (2.0-2.35 tha^{-1}) of Sunflower (BRAC Hysun-33) could be obtained with the application of mulches (water hyacinth) and gypsum fertilizer@ 100 kg ha^{-1}
- Higher yield (8.5 - 8.9 tha^{-1}) of Maize (NK-40) could be obtained with the application of gypsum fertilizer (@ 100 kg ha^{-1} ;and mulching (water hyacinth)
- Higher Benefit Cost Ratio (BCR) of T. aman rice (1.35), Boro rice (1.29), Sunflower (2.58) and Maize (1.97) could be obtained through application of Climate Smart Technologies (improved varieties / species, furrow transplanting, mulching and gypsum fertilizer).

Researcher:

Dr. Md. Abdul Kader
Professor, Department of Agronomy
Bangladesh Agricultural University
Mymensingh-2202
Mobile: 01724-828058, E-mail: abdul.kader@bau.edu.bd

Productivity Enhancement of Kenaf in Char Lands

Introduction

Kenaf can be grown in the marginal lands with minimum care compare to jute and capable to provide high yield even in the char lands of Bangladesh. The prices of jute and Kenaf fibres are oftentimes similar, and as a consequence, Kenaf can replace jute in the char areas without complexity. Sandy medium high to low lands in char areas is not commonly suitable for jute production because of severe occurrence of stem rot, die back and other diseases, whereas kenaf can be grown effortlessly in such type of lands due to its resistance to diseases. In Bangladesh, substantially large number of char lands is existed in northern region in particular where thousands of hectares of land remain fallow during jute growing season. Farmers cannot grow jute in these areas due to infection of different diseases. Kenaf can be cultivated at minimum management practices as alternate crop of jute as well as fallow lands would be utilized for maximizing economic return. Hence, it is imperative to identify the Kenaf variety and Kenaf based cropping pattern as well as to find out suitable Kenaf seed threshing technique that enhance seed production and uphold quality of seed for such landscape.

Description of the Technology

- Introduction of improved cropping pattern of Potato (BARI Alu -25) - Kenaf (BJRI Kenaf -3) - T. aman (BRRI dhan 49) under Cha r land areas against the existing cropping pattern of Potato (Local) – Jute (O-9897/JRO-524) - T. aman (BRRI dhan 49/ BRRI dhan11 / Swarna) is recommended for the Char land areas of Kurigram and Ghaibandha for increasing productivity and farmers income
- BJRI Kenaf - 3, BJRI Kenaf - 4 and mechanical method of threshing without drying is recommended for maximizing best quality seed production of Kenaf in late season at Char areas
- Seeds of Potato and Kenaf are to be planted/sown in the 1st week December and 1st week of May while the said crops could be harvested in March and 1st week of August , respectively
- Seedlings of T. aman rice need to be transplanted between July and August while it can be harvested in the last week of November
- Fertilizers and manures are to be applied according to Fertilizer Recommendation Guide, 2018 with urea, triple super phosphate (TSP), muriate of potash (MoP) and gypsum@180-50-20-50 kg ha^{-1}, respectively. All the fertilizers except urea are to be applied during final land preparation. Urea would be given as top dress in three equal splits at 15, 30 and 45 days after sowing of kenaf seed
- Intercultural operations as well as spraying of insecticides and fungicides need to be done as and when necessary as per BJRI recommendation. Weeding need to be done by hand at 30 days after sowing (DAS) of kenaf seed and thinning should be done to maintain plant to plant distances of about 15 cm along with the weeding operation.

Benefit of the Technology

- Higher fibre yield (3.9 t ha^{-1}) and seed yield (1036 kg ha^{-1}) of Kenaf (BJRI Kenaf 3) could be obtained from charland of Kurigram and Gaibandha districts than that of Jute
- Higher yield of potato (24.32 t/ha), kenaf (3.52 t/ha) and T.aman(4.43 t/ha) could be obtained from the developrd alternate cropping pattern over the existing cropping pattern potato (14.8 t/ha), jute (2.35 t/ha) and T.aman (4.13t/ha) respectively
- Higher gross return and gross margin could be obtained from the developed alternate cropping pattern: Potato-Kenaf- T. aman over the existing cropping pattern:Potato-Jute-T.aman
- Seed threshing of kenaf through mechanical method would be more efficient than traditional method
- Higher BCR of Kenaf (1.99) could be obtained than that of jute (1.5) in char land of Kurigram and Gaibandha districts while the higher BCR (2.85) would be obtained from the developed alternate cropping pattern over the existing cropping pattern (1.71) in the said area.

Researcher:

Dr. Md. Abul Fazal Mollah
Principal Scientific Officer
Bangladesh Jute Research Institute
Regional Station, Rangpur
Mobile: 01718-616035; Email: mollahabulfazal@yahoo.com

Productivity Enhancement of Saline Areas through Underutilized Crops

Introduction

In the saline char areas of Noakhali region, soil salinity increases progressively through capillary movement and reaches peak in around Mid-March to April which diminishes with the onset of monsoon and allow farmers to grow T. Aman. However, vast coastal saline land remains fallow after harvesting of T. Aman in the upazila namely Subarnachar, Companigonj and Hatiya due to salinity, scarcity of quality irrigation water and irrigation facilities, poor knowledge about agronomic management of salt affected land and inadequate salt tolerant varieties etc. Consequently, the predominant cropping pattern is Fallow - T. Aman - Fallow, although double cropping (Fallow-T. Aman-Rabi crops) is practiced in some areas, triple cropping (T. /D. Aus - T. Aman-Rabi crops) is rare. Despite all these constraints, the area has much potential and opportunities to increase productivity through selecting and cultivating agro-ecologically suitable underutilized crops such as Barley, Foxtail millet, Proso millet, Sorghum, Safflower and Linseed. Under such sceneries, it is necessary to increase crop production by means of crop diversification along with good agronomic practices in slightly and moderately fallow saline area through participatory approaches.

Description of the Technology

- Among six (06) underutilized crops, four (04) crops namely-Proso millet, Safflower, Sorghum and Linseed are recommended for cultivation in moderate to strong saline (6.1 to 12 dSm^{-1}) areas. Barley is suitable for moderate saline (6.1to 8 dSm-1)areas whereas Foxtail millet is suitable for slightly saline (4 to 6 dSm^{-1}) areas
- Out of twenty seven (27) cropping systems, twelve (12) systems are promising for coastal area of Noakhali. Among the cropping systems Linseed (100%) + Mustard(30%) and Linseed (100%) + Grasspea (30%) are mixed cropping system; Linseed + Safflower (2:1), Sorghum + Grasspea (2:3), Sorghum + Cowpea (2:3), Safflower + Linseed (2:2), Safflower + Mustard (2:2), Safflower + Sorghum (1:1), Safflower + Cowpea (2:2), Safflower + Grass pea (2:2) are intercropping systems and Linseed surrounding by Safflower, Linseed surrounding by Mustard are border cropping system found economically viable for scaling up in similar agro-ecological zones
- The suitable sowing time of all the crops mentioned above is the last week of November and the harvesting is done within 95 days to 120 days after sowing depending on the maturity of the crops and the suitable locations are the saline char areas of greater Noakhali
- The fertilizer and manures are to be applied according to Fertilizer Recommendation Guide, 2018 with urea, triple super phosphate (TSP), murate of potash (MoP) and gypsum, respectively. All fertilizers except urea are applied during final land preparation. Urea would be given as top dress in three equal splits at 15, 30 and 45 days after sowing
- Intercultural operation i.e. irrigation, thinning, as well as spraying of insecticides and fungicides are to be given as and when necessary as per BARI recommendation. Weeding to be done by hand at 30 days after sowing (DAS). Thinning need to be done to maintain plant to plant distance of about 15 cm along with the weeding operation.

Benefit of the Technology

- Higher yields of BARI Barley - 6 (1.21 tha^{-1}), BARIKaon-2 & 3 (1.32 tha^{-1} and1.17 tha^{-1}), Proso millet (BARI Cheena-1 yielded 1.25 tha^{-1}) and Sorghum (ICS-191153 gave 1.78 tha^{-1}), BARI Saff-1 (1.03 tha-1) and BARI Tishi-1 (0.92 tha^{-1}) could be obtained in moderate to strong saline conditions as well as economically profitable.

Researcher:

A.H. Md. Amir Faisal
Scientific Officer, On-Farm Research Division
Bangladesh Agricultural Research Institute
Maijdee Bazar, Noakhali
Mobile: 01711-032777, Email: faisalofrd@yahoo.com

Improved Cropping Pattern for Productivity Enhancement in Coastal Areas

Introduction

The coastal area of Bangladesh has less cropping intensity (133%) due to dry season salinity of soil and water along with other severe constraints like tidal flood, late drainage, heavy clay basin, scarcity of quality irrigation water, late rainfall etc. The present land use in this area consists mainly of growing one T. Aman rice (Traditional) and occasionally in some places Rabi crops with poor management practices. About 53% of arable land remains fallow in seven coastal districts during Kharif-1 season and 34% in Rabi season. Inclusion of short duration and salt or flood tolerant HYV Aus and Aman rice, heat and / or salt tolerant late Rabi crops, strip tillage, mulching are some of the agronomic options towards increasing productivity and cropping intensity in coastal ecosystem.

Description of the Technology

- Introduction of improved cropping pattern : T. Aus rice (BRRI dhan55) - T. Aman rice (BRRI dhan77)-Sunflower (Pacific Hysun 33) is recommended in non-saline ecosystem for increasing production per unit area
- Transplanting time of T. Aus and T. Aman rice seedlings are 2nd to 3rd week of May and 3rd week of August, respectively and the said crops could be harvested in 2nd week of August and 2nd week of December, respectively
- Sowing time of sunflower seeds is 2nd-3rd week of January
- Strip tillage with crop residue retention (15-20 cm) should be practiced in Sunflower for moisture conservation
- Mulching material (dry rice straw) @ 5 tha^{-1} should be applied in case of traditional tillage in sunflower after germination for moisture conservation
- Manures and fertilizers for T. Aus,T. Aman and Sunflower should be applied as per recommendation of Fertilizer Recommendation Guide, 2018
- Other cultural operations of rice should be done according to 'Adhunik Dhaner Chash' published by BRRI 2017 and those of sunflower according to 'Krishi Projukti Hatboi' published by BARI, 2000 as and when necessary
- Suitable area for adopting the technology would be medium high land of coastal areas.

Benefit of the Technology

- In non-saline ecosystem, 297-305% higher rice equivalent yield could be obtained from T. Aus rice (BRRI dhan55) - T. aman rice (BRRI dhan77) - Sunflower (Pacific Hysun 33 with strip tillage or mulching) cropping pattern over farmers' practice Fallow-T. aman (Moulata) - Mungbean (BARI Mung-6). The higher gross margin (Tk. 199950-229651 tha^{-1}) and BCR (1.77 - 1.98) could be obtained from the same cropping pattern over existing cropping pattern
- In saline ecosystem, 250-253% higher rice equivalent yield could be obtained from T. Aus rice (BRRI dhan55) - T. aman rice (BRRI dhan73) - Sunflower (Pacific Hysun 33 with strip tillage or mulching) over Fallow - T. aman (Swarna) - Fallow cropping pattern (Farmers' practice). The higher gross margin (Tk. 181990-191835 tha^{-1})and BCR (1.74-1.82) could be obtained from the same cropping pattern over the existing one.

Researcher:

Dr. Swadesh Chandra Samanta
Professor, Department of Agronomy
Patuakhali Science and Technology University
Dumki, Patuakhali
Mobile: 01738-811079, Email: samantapstu@yahoo.com

Safe Vegetable Production in Urban Area through Vertical Farming

Introduction

Bangladesh is a densely populated country in the world. To achieve the sustainable nutritional security, it has changed from a single focus on rice to diversify with high value crops. Different types of vegetables play a key role in this effort. Bangladesh produces 156 types of vegetables with 1.42 core tones per year (The Daily Star, 27.11.19). In fact, year round and organic and pesticide free vegetable production is still facing challenges. Moreover, increasing urbanization (3.55%) in Bangladesh will consume huge arable land which may compel to import vegetables in near future from other countries. Introduction of vegetable cultivation through multi layer vertical farming system can be used in urban areas of the rooftop for safe vegetable production to ensure the nutritional security.

Description of the Technology

- Multilayer vertical framing system can be used in the rooftop of urban areas for the production of safe nutritious and short duration vegetables. A rectangular vertical steel frame (6.4 feet × 5 feet × 1.8 feet) having four stands need to be established. This frame should be made with three vertical layers and four parts in its one layer. Portable perforated hard plastic trays with 8 cm culture media/substrate layers should be used for the cultivation of vegetables. Another steel tray should be used beneath the portable hard plastic tray for drainage the water Vegetable crops could be grown in four culture media viz. soil, Soil + Vermicompost (3:1), Soil + Coconut coir (3:1), Vermicompost+Coconut coir (1:1)
- Soil with vermicompost (Soil + vermicompost) could be used as culture media / substrate in the vertical frame for the production of lettuce (Lactuca sativa), pak-choi (Brassica rapa), red amaranth, (Amaranthus gangeticus), spinach (Spinacia oleracea), french bean (Phaseolus vulgaris), indian spinach (Basella alba), mint (Mentha aquatica), thankuni (Centella asiatica) and water spinach (Ipomoea aquatica). Soil with coconut coir (Soil + cocoonut coir) could also be used as culture media / substrate for the production of french bean (P. vulgaris) in both summer and winter seasons
- Lettuce, red amaranth, pak-choi and spinach could be recommended for cultivation in soil + vermicompost media and french bean in soil + coconut coir culture media during winter for higher yield
- Higher nutritional content of lettuce, Pak-choi, red amaranth, french bean, indian spinach, mint, thankuni, water spinach could be obtained through using soil + vermicompost substrate
- In the vertical structure, lettuce, Pak choi, red amaranth, french bean could be grown in winter whereas indian spinach, mint, thankuni, water spinach could be grown in summer. In winter season, Ca, Mg and P rich red amaranth, K and S rich pak-choi, Fe, Mn and Zn rich lettuce , Na and B rich spinach could be grown in soil + vermicompost substrate in vertical frames. In summer season, Mg rich water spinach, P rich indian spinach, Ca, K and S rich thankuni could be produced in soil + vermicompost substrate of vertical frames
- Intercultural operation i.e. irrigation ,drainage, thinning etc need to be done as and when required
- Rooftops gardening of urban areas are suitable for safe vegetable production

Benefit of the Technology

- Higher yield of lettuce, Pak-choi, red amaranth, french bean, indian spinach, mint, thankuni, water spinach could be obtained when this would be grown in soil + vermicompost substrate in vertical frames. Moreover, higher yield of french bean could also be obtained in soil with coconut coir (Soil + coconut coir) substrate
- Increased growth of Indian mint and Indian spinach could be obtained in both soil + vermicompost and vermicompost + coconut coir culture media. However, water spinach and thankuni growth would be significantly increased only in soil + vermicompost culture media
- Availability of safe vegetables would be increased all the year round which will ensure the nutritional security through consuming the fresh safe vegetables by urban people of their rooftop more efficiently as well as increase the land use efficiency.

Researcher:

Dr. Md. Fuad Mondal
Assistant Professor,
Department of Entomology
Faculty of Agriculture, Sylhet Agricultural University, Sylhet
Mobile: 01922-934568, Email: fuadentom@yahoo.com

Mechanical Coconut De-husking Machine (ID-307)

Introduction

Coconut (*Cocos nucifera* L.) is a popular and common fruit in Bangladesh. About 0.41 million tons of coconut is produced annually in Bangladesh. Coconuts are cultivated more or less all over the country. After harvesting of coconut, husk needs to remove for selling in market for consumption and making oil. De-husking of coconut is one of the most crucial agricultural postharvest operations which is precise but drugdery, labour and cost intensive operation, mostly done manually in Bangladesh. Now- a- days, labour crisis is acute as rural labour are migrating to urban area for getting better wage in industry and service sectors. So, the use of agricultural machinery will be helpful to mitigate the labour crisis. Introducing an automated coconut de-husking machine in the farm areas can reduce the risk involved in the use of spikes in de-husking the coconut and also eliminates the skilled manpower required for de-husking the coconuts. This machine is useful for the coconut traders who sell de-husked coconut in the market. Most of the farmers and traders use traditional tools Dha, Sarasi and Khanti for de-husking of coconut respectively. Retailers sold 66% coconut with husk and 34% coconut without husk. All traders of Khulna area used to de-husk coconuts using Khanti. De-husking capacities of Dha, Sarasi and Khanti varied from 20 to 25 nuts/hr, 43 to 75 nuts/hr and 100 to 175 nut/hr, respectively. Therefore, a power operated coconut de-husking machine having high capacity is urgently needed which will save both time and money.

Description of the Technology

- A power operated coconut de-husking machine is fabricated with the locally available raw iron materials
- It is made of SS pipe, SS spike, SS blades, SS angle bar, SS shaft, SS sheet, SS plate, motor, belt-pulley, chain sprocket, gear reducer, pinion etc. Main working parts of the machine are rotating blade roller, motor, chain sprocket
- De-husking capacity of the machine is 309 nuts/hour, Roller speed is 25 rpm, Breakage is 3 – 6% and the weight of the machine is 258 Kg
- De-husking cost is 0.28 Tk/nut, payback period 116 days, benefit cost ratio 1.25, break even point 775 hours and price of the machine is BDT 1.0 (one) lakh. Therefore, coconut de-husk by using the de-husker could be profitable to traders when the annual use of the de husker exceeds 775 hours
- Farmers, traders and manufacturers of all over Bangladesh can use the machine for coconut de-husking to reduce drudgery and cost which will help to increase productivity and income. Specially, traders of coconut growing areas of Barishal, Khulna, Noakhali, Patuakhali, Pirojpur and other coconut growing areas of Bangladesh can use the machine
- The machine has to be placed on plain surface, open space and shady place. The motor has to be started & stopped by means of OFF-ON switch. Later one operator has to place one by one coconut between the two rollers and immediately press the coconut upper surface by lever. Coconut is de-husked by the action of two spike/blade roller those are rotating opposite direction to each other. The husk is drained out in the basket through delivery path.

Benefit of the Technology

- Capacity of the machine is more than double that of traditional practice
- The machine is fabricated with locally available materials
- It can save 57% money and 50% time compared to traditional practice
- De-husking cost is comparatively low (0.28 Tk./nut) and Benefit cost ratio is 2.0.

Researcher:

Dr. Md. Nurul Amin
Senior Scientific Officer
Farm Machinery and Postharvest Process Engineering Division
BARI, Joydebpur, Gazipur-1701
Mobile: 01717-734248, Email: naminbari@gmail.com

Improved Coconut Harvesting Machine (ID-307)

Introduction

Coconut (*Cocos nucifera* L.) is a popular and common fruit in Bangladesh. About 0.41 million tons of coconut is produced annually in Bangladesh. Coconuts are cultivated more or less all over the country. Unfortunately, despite its mass distribution and wide spread around the world, coconut harvesting is still done without proper safety measures which can lead to serious injuries. It is very difficult to climb on coconut tree manually due to the constant cylindrical structure and single trunk. It is very hard to learn the necessary skills to climb coconut trees. Now- a- days, different types of coconut harvesting methods are used in other countries of the world like India, Malaysia, and Sri Lanka. But a very few are capable of climbing trees, main reason being irregular surface and variation of diameter with length. Also the bark of some trees may not be strong enough to bear the weight of the climbing device, hence conventional climbing robots cannot be used for tree climbing applications. In Bangladesh, coconut growers know how to cultivate the coconut but generally they harvest the coconut mainly by climbing on tree which is very risky. As the coconut trees are very tall so injuries associated with coconut tree climbing, particularly falling from coconut trees is a common phenomenon. Climbers get scratched hands, legs and chest during climbing on and climbing down from the tree Due to the risk involved very less people are coming forward to climb on coconut trees. Therefore, an improved coconut tree climber is urgently needed which can help the user to climb coconut tree easily and safely.

Description of the Technology

- The machine is standing type manual operated coconut tree climber
- It consists of two parts. One part is used in left leg and another part is in right leg. The parts of the machine are independently movable and positionable along the coconut tree trunk
- The tree gripping section of the machine consists of stainless steel wire and rubber tires
- The functional parts of the machine are left and right handle, foot holder, tree holder, wire etc.
- The dimension of the climber is 1070×100×Ø10 mm
- One person can easily operate this machine
- The total weight of the machine is 9 kg
- **Working Principle:** Coconut tree climber has mainly two assemblies of similar fabrication. The user has to maintain these two assemblies simultaneously by using hands and legs to climb on different size and shape of coconut tree. The user has to stand and operate the device. Initially the steel wire of both the assemblies has to be looped with the tree and to be locked. One person can stand by placing foot on both assemblies and has to hold on the handles. As the user raise the assembly by foot and by hand the steel wire will get loosen and when he push back with foot after reaching to a particular height it is got tighten. By this process the user can climb the tree easily. The descending the tree is exactly the reverse procedure. The machine works on the body weight and the steel rope wire and got adjusted as per diameter of the tree by the force applied by the user towards gravity.

Benefit of the Technology

- The coconut tree climber can climb the tree easily and safe.
- It is portable and the machine life is 5 years (working duration 250 days per year).
- The cost is not very high (Tk 8800)

Researcher:

Dr. Md. Nurul Amin
Senior Scientific Officer
Farm Machinery and Postharvest Process Engineering Division
Bangladesh Agricultural Research Institute, Joydebpur, Gazipur-1701
Mobile: 01717-734248, Email: naminbari@gmail.com

Power Operated Oil Palm Fruit Stripper

Introduction

Bangladesh has been turned into one of the biggest markets of edible oil and about 15-16 lakh tons of edible oil is imported every year. Recently government has given priority for oil palm plantation in order to meet up the country's emerging need for edible oil on the one hand and reduce the use of valuable foreign currency for import on the other. In this connection, huge numbers of oil palm plantation have been established all over the country. However, absence of suitable palm oil processing technology (crude oil from FFB), a lot of fresh fruit bunch (FFB) are wasted. Stripping of palm fruits from the bunch is an important step in palm oil processing technology. Manual stripping is laborious, time consuming and health hazard task, moreover, it gives poor quality of oil and reduces oil extraction rate. Hence, it is important to separate palm fruit from bunches mechanically and be processed as soon as possible to prevent a rapid rise in free fatty acid which normally affect the quality and extraction rate of crude palm oil. Therefore, oil palm stripper is an important machine that could be used to separate palm fruits from bunches for profitable and sustainable palm oil processing of medium scale palm oil processors.

Description of the Technology

- The stripper consists of four basic units- feeding unit, stripping chamber, drive mechanism, discharge outlet (Fig 3). The cylinder diameter is 580 mm and the height is 460 mm which is suitable for both small and medium scale palm oil processing mill
- The cylinder is setup on a support frame. Four biters are attached with the shaft according to design (Fig. 1)
- A 4.5 Hp motor is used to supply the power. V-Belt and pulley is used for power transmission which converts the motor rpm to the shaft rpm at 450 (Fig. 2)
- The necessary steps are: Fruit collection Sterilization at 110-120^{0}C temperature for 10 minutes Placing the sterilized fruits in stripping chamber Collection of separated fruits Sorted out the good and injured fruits.

Fig. 1: Cylinder

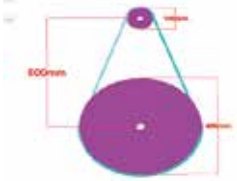

Fig.2: Power transmission system

Fig. 3: Palm fruit stripper

Benefit of the Technology

- The machine is portable and environmental friendly
- The machine could be operated easily without Expert
- The machine capacity is 0.81 ton/hr, which is equivalent to 54 labors
- The BCR of the machine is 1.85
- Injured fruits percentage is only 0.14%
- Reduce the cost and time to separate the fruits which will ensure quality oil and make the palm oil production more profitable
- Income Generating Activity (IGA) and entrepreneur development

Researcher:

Dr. Md. Abdul Awal
Professor, Department of Farm Power and Machinery
Bangladesh Agricultural University, Mymensingh-2200
Mobile:01710-987258, Email: awalbau@gmail.com

Productivity Enhancement of Lac through Modern Production Practices

Introduction

Lac is a natural resin secreted by tiny lac insect, Kerria lacca(Kerr). It can be considered as the promising cash crop in Bangladesh, growing in Rajshahi-Chapainawabgonj region since long time. It is widely used in paint and varnishing, ornaments, cosmetics, electric insulation, pharmaceutical industries, jewellery industry, chocolate and fruit coating, urea coating, tannery industries, automobile industries, machine-tool factories, textile industries etc. Farmers are using traditional production technologies and getting less benefit. Promotion of the modern lac cultivation technologies in existing lac producing area as well as new promising areas of the country undoubtedly will increase lac production, uplift income generation and create employment opportunities for ultra-poor and marginal farmers.

Description of the Technology

- Lac insects are generally cultured on host plant like Jujube/ ber (Zizyphus jujuba/ Zizyphus mauritiana), babla (Acacia arabica) and rain tree (Samania saman). But, jujube/ ber is being widely used for lac cultivation. Selection of suitable host plants for different regions will enhance the production of lac
- Apple kul and BAU kul have been selected as good host plants of lac for Jamalpur region while ber, rain tree and babla are recommended for Chapainawabganj region
- Proper time of host plant pruning for kartiki and baishakhi lac crops are the last week of February and the end of April, respectively. Branches more than two inches (5 cm) in diameter must not be cut
- The host plants should be inoculated by healthy brood lac in June for kartiki crop and in November for baishakhi crop. During inoculation, the broodlac sticks should be tide onto the host branches both vertically and horizontally, so that the young shoots get full inoculation. Generally, lac nymphs coming out of a one feet (30 cm) long brood lac stick can inoculate 15-20 feet (4.5-6.0 m) young tender shoot of the host plant
- Recommended fertilizers and irrigation should be applied to the host plants to enhance new shoot growth. Specially, in baishakhi crop season, irrigation is important during extreme hot (above 350 celcius) weather condition in March - May
- Two to three application of neem seed extract @ 10g crushed seed/litre of water at an interval of 30 days starting from the first incidence of predators is recommended for effective control of lac predators (Eublemma amabilis and Pseudohypatopa pulveria) and increased yield
- Proper time for the harvesting of kartiki lac crop is November and that of baishakhi crop is June when lac nymphs start swarming

- Processing starts with the scrapping of the stick lac from the twig. Scrapped lac must be cleaned of the impurities like dead lac insects, eggs and other debris. After cleaning the lac is to be grinded by grinding machine and washed in water for several times. Then the lac is to be air dried after which it forms pale yellow colored granules called seed lac. This seed lac is then to be put into a long cloth bag and heated to melt in on charcoal fire. During heating the bag is to be twisted and the lac is to be squeezed out of the bag leaving impurities inside. This melted lac is then to be allowed to different devices to get different forms like button lac, shellac, etc.
- Technologies are suitable for the lac growing areas of Bangladesh.

Benefit of the Technology

- Higher yield of lac in rain tree (15.5 – 17.75 kg/tree), ber (5.75 – 6.8 kg/tree) and babla (4.25 – 4.8 kg /tree) could be obtained with the use of modern production practices
- Higher MBCR (5.79) would be obtained from the tree spraying with neem seed extract @ 10g seed/litre of water than the insecticides
- Un-employed, ultra poor and marginal farmers will be able to earn money from lac cultivation.

Researcher:

Dr. Debashis Sarker
Chief Scientific Officer,
Entomology Division, BARI, Gazipur-1701
Mobile:01712-274933, Email: dsarker@gmail.com

Shelf Stable Value Added Products of Onion, Garlic and Ginger

Introduction

Onion, garlic and ginger are available in large quantity during the harvesting season. Huge supply during peak season is responsible for lower market price. Farmers are using traditional storage. Thus, a significant amount of (20-30%) onion, garlic and ginger are rotten in the store. So the country needs to take all out measures to reduce the losses /spoilage to an acceptable level to meet the shortage. Thus, there is no alternative but to process and preserve the above spices. Unfortunately, till now there are no remarkable technologies to minimize these losses. Therefore, it is necessary to take appropriate measures to reduce the losses /spoilage to an acceptable level by processing and preservation of onion, garlic and ginger.

Description of the Technology

- Good quality powder made from summer onion, garlic, and ginger by mechanical and /or solar drying with pretreatments such as osmotic dehydration, blanching and sulphiting has a good prospect to be produced commercially in large scale and medium scale industries.
- Home level or cottage level industries may also be effective to produce dehydrated powder with or without pre-treatment
- The commercial production of processed onion, garlic and ginger will get from raw condition with its natural colour and flavor with a potential prolong shelf life
- Method of onion processing are: Raw material receiving ➡Cleaning➡ sorting/grading➡ removal of skin, roots and tops➡sulphiting (with 1500 ppm K2S2O5 for 6 hrs)➡chopping/slicing (3-5 mm thick)➡draining➡washing➡ keeping in salt solution for osmosis (10% salt solution, 6 hrs)➡placing the slices to a perforated pot to remove water➡spreading the slices on tray with polythene paper➡drying (60-650C) in mechanical dryer upto 6-8% moisture content➡grinding cooling in room temperature➡Packaging (HDPE, Foil/plastic pot/Tin container)➡ store in refrigerator (5-100 C) or room temperature
- Method of garlic and ginger processing are: Raw material receiving➡Cleaning➡sorting/grading➡peeling➡ chopping/slicing(only ginger will be sliced 5 mm thick)➡sulphiting (with 1500 ppm $K_2S_2O_5$ for 6 hrs)➡washing➡ placing the slices to a perforated pot to remove water➡washing➡keeping in salt solution for osmosis (10% salt solution, 6 hrs)➡spreading the slices on tray with polythene paper➡drying (60-650C) in mechanical dryer upto 6-8% moisture content➡grinding➡sieving➡cooling in room temperature➡Packaging (HDPE, Foil/plastic pot)➡ store in refrigerator (5-100 C) or room temperature.
- These processed products may be used at home as well as in the catering centers such as hotels, restaurants, canteens, hospitals, nursing home, prisons and other establishment
- The prepared processed products, for its anticipated widespread use, may help to fill the needs of consumers for convenient food ingredient
- High quality shelf-stable onion, garlic and ginger powder can be developed utilizing available low cost dehydration processes and thereby, post-harvest losses of these spices can be reduced to an acceptable level
- Onion, garlic and ginger powder packed in aluminium foil and stored at room temperature or refrizeration temperature are most acceptable and shelf life is more than one year.

Benefit of the Technology

- Since post-harvest loss would be drastically reduced and farmers would get proper price for their product and as a result total production of onion, garlic and ginger would be increased and sustained
- A large number of skilled and semi-skilled or even unskilled persons would be employed in the relevant plant/industries.
- Value added product such as dehydrated and processed onion, garlic, and ginger powder can be sold profitably in off-season in both local and foreign market. Thus Bangladesh can earn foreign exchange which is very much needed for industrial and socio-economic development.

Researcher:

Dr. Md. Masud Alam
Senior Scientific Officer
Spices Research Centre
BARI, Shibganj, Bogura
Mobile: 01715-917957, Email: mmalam2569@yahoo.com

Fresh Cut Processing Technologies for Fruits and Vegetables

Introduction

The consumption of fresh fruits and vegetables are growing as consumers become more aware about its health benefit. Increasing urbanization, changes in life style and involvement of more women into jobs has forced to find out easy way to get safe and nutritious foods. Fresh cut fruits and vegetables (FCFV) may be an alternative to meet this situation. FCFV has been physically modified (by peeling, trimming, washing and cutting) to obtain 100% edible product that is subsequently packaged and kept in refrigerator. However, it is difficult to preserve the quality of fresh cut fruits and vegetables. Fresh cut (FC) products are highly perishable due to the disruption of tissue and cell integrity, with a concomitant increase in the enzymatic, respiratory and microbiological activity, which reduce the shelf life of these products. Fresh cut processing technologies of fruits and vegetable may be an alternative to get safe and long shelf life nutritious food.

Description of the Technology

- Fresh cut processing techniques of carrot, cauliflower, green bell pepper, pineapple, jackfruit and strawberry:
- At first fresh cut (FC) processor should wash hands with soap properly and wear apron, cap, musk and hand gloves. All used utensils and whole fruits or vegetables should be washed using 200 ppm sodium hypochlorite (3.5 ml Clorox/litre) or 0.1% calcinated calcium (1 g/litre)
- Carrots to be peeled with hand peeler and trimmed of tap root and cut into 1 cm thick round shape. Carrot slices should be treated with warm (60°C) solution of 2% NaCl (table salt) or warm (60°C) solution of 2% citric acid for 1 minute. After removing surface water, 100g slices need to be kept into polypropylene (PP) clear box, closed and kept in refrigerator (4±1oC). Carrot treated with warm solution of 2% NaCl would be acceptable up to 8 days while carrot treated with warm solution of 2% citric acid would remain acceptable up to more than 10 days during storing at refrigerator(4±1°C)
- Washed cauliflower and green bell pepper to be cut into 100 gm small pieces. After removing surface water,100 g cauliflower or bell pepper pieces need to be kept open or into polypropylene box and wrapped with cling film or into Low Density Polyethylene (LDPE) bag (25 µm) and closed by stapling and performed vacuum. All packets are to be kept in refrigerator (4±1oC). FC cauliflower kept in Styrofoam tray/ polypropylene box and wrapped with cling film one will be good up to 16 days and vacuum packed cauliflower will be good up to more than 20 days. FC bell pepper kept in Styrofoam tray/ polypropylene (pp) box wrapped with cling film one will be good up to 8 days and vacuum packed FC bell pepper will be good up to more than 10 days
- Skin of washed pineapple should be removed with a sharp knife, quartered and sliced transversely (5 mm thick). Jackfruit (Khaja) bulbs to be collected from fruits and seeds will be removed. Suitable amount of FC pineapple or jackfruit bulbs should be washed with sanitizers (0.1% calcinated calcium or 2% citric acid solution) and are to be kept into PP box, closed and put into refrigerator (4±1°C). Fresh cut pineapple and jackfruit bulb will be good up to 5 and 9 days respectively.
- Whole washed strawberries to be dipped into Aloevera gel for coating. After drying of surface coating, strawberries are to be kept into PP box and stored in to refrigerator (4±1°C). Strawberry coated with Aloe vera gel will be acceptable for more than 9 days.

Benefit of the Technology

- Fresh cut processing technologies of fruits and vegetables will help to get safe and nutritious food
- Benefit cost ratio of sodium chloride treated fresh cut carrot = 1.46: 1
- Benefit cost ratio of vacuum packed fresh cut cauliflower = 1.88: 1
- Benefit cost ratio of vacuum packed fresh cut green bell pepper = 2.77: 1
- Benefit cost ratio of Fresh cut pineapple = 1.9: 1
- Benefit cost ratio of fresh cut jackfruit bulb = 1.96: 1
- Benefit cost ratio of Aloe vera gel coated strawberry= 1.77: 1

Researcher

Dr. Taslima Ayesha Aktar Nasrin
Senior Scientific Officer, Postharvest Technology Section
HRC, BARI, Joydebpur, Gazipur-1701,
Mobile: 01715-904470, Emai: taanasrin@gmail.com

Gummosis Disease Management of Shade Trees in Tea Plantation

Introduction

Tea (Camellia sinensis L.) is one of the oldest and most popular and favorite beverage (nonalcoholic) in the world. It plays an important role in Bangladesh's economy. Tea is a shade loving plant. For better tea production 50-70% diffused sunlight is needed. If the intensity of sunlight is reduced, production increases up to 40%. Shade trees are those trees, which are used for providing shade over the tea plantation. The shade trees provides 50 to 70 % of diffused solar insolation to the tea cultivation area. It results in improved quality of the tea leaves due to increase in the concentration of amino acids with lowers content of catechin in the plant and it also inhibits the concentration of flavonoid. In Bangladesh, there are 166 tea estates and 746 small growers of tea all over the country. The shade trees play an important role in increasing productivity of the tea under the environment of Bangladesh. Without shade trees, yield of tea is limited. Thus to increase tea yields, a large number of shade tree species are planted in various tea garden of Bangladesh. Now-a-days, gummosis is a very common disease of shade trees in the tea garden of Bangladesh in which rotting of bark takes place and gum exudates from the affected areas causing weakness the trees and the tree may die.

Description of the Technology

- Tree trunks and branches should be monitored regularly to detect infestations before they become serious Badly cankered limbs need to be pruned out and destroy as well as good orchard sanitation should be practiced Mechanical injuries to trunk and roots need to be avoided.
- Tree health should be maintained with good silvi cultural practices. Tree should be monitored routinely for symptoms and manage the fertilization and irrigation system properly. Manure and fertilizers should be applied according to soil test recommendations. Late summer fertilization should be avoided
- Borer insect need to be controlled by spraying the bark with 0.1% dieldrin or Malathion. Inject 5 ml of 0.1 % dichlorvos into larval hole or plugging the larval hole with cotton soaked with kerosene will be found superior. Avoid pruning trees when borer adults are flying, usually late winter through late summer Replace old declining trees.
- Before sowing of seeds in the nursery, the seeds should be treated by recommended chemical fungicide or Trichoderma. Healthy and pathogen free plantlets should be selected for planting.

Chemical control:

- When the disease is in progress in infected trees, disease portions should be scraped-out with a sharp knife and the cut surface will be disinfected with Mercuric chloride (0.1%) or Potassium permanganate solution (1%) using a swab of cotton. After that, infected portion should be painted with Bordeauxpaste (2%) for four month
- When disease becomes clear in the trunk and branches chemical fungicides Bordeaux mixture (2%)/Autostin (Carbendazim) /ARBA (Carbendazim)/ Knowing (Carbendazim) @ 2 g/l should be sprayed at 7 days interval upto four months

Biological control:

- When the disease is in progress in infected trees, disease portions should be scraped-out with a sharp knife and liquid formulation of Trichoderma@5 ml (5×10^5 conidia/ml) should be sprayed at 7 days interval in the lesion for four months

Benefit of the Technology

- Proper shade management will be ensured by adopting proper disease management technique of shade trees in tea garden of Bangladesh. As a result, the production of tea will be increased. On the other hand, other demand like timber, fuel wood, medicine etc. will be achieved. Ultimately, farmer's income will be increased. That will lead to economic development of the country
- Disease will be reduced by application of recommended chemical fungicides which will protect the tree from dying
- Trichoderma can be used as potential biocontrol agent to control this disease. The bio-agents may be used for plant disease management to diminish our economic loss and overcoming any environmental risk.

Researcher:

Dr. M. Ahsanur Rahman
Senior Research Officer, Forest Protection Division
BFRI, Sholosohar, Chattagram
Mobile:01718-084069, Email:bappy43@yahoo.com

Development of Moringa Based Agro-forestry System for Sustainable Livelihood

Introduction

Moringa is one of the most useful trees in the world since every part of the tree is used as food, fodder, medicine, and industrial purposes. In Bangladesh, Moringa is sporadically cultivated in and around the homestead. Moringa cultivation in association with crops is rare across the country. Moringa can be grown in association with agricultural crops as it is deciduous as per understory crop will not be hampered and get sufficient sunlight, water and nutrients. If compatible Moringa–vegetable cropping pattern could be developed and up-scale it to the farmers by further research activities for boosting total productivity as well as income of the farmers.

Description of the Technology

- For selecting potential moringa landrace for multipurpose uses, moringa mother plants are to be selected by considering fruit size, shape, fruiting behavior, yield as well as for biomass production
- Branch cuttings should be collected from the selected landrace a few days before planting
- For tree establishment, 50 cm deep cubic size pits should be dug at 5 feet (1.50 m) distance from pit to pit
- All the cuttings should be 4.0 feet (1.20 m) in length and are to be placed separately at the center of each pit
- The field should be prepared by spading. After spading, the land should be kept fallow for one month
- During this time all crop residues, weeds, broken stones and bricks are to be sorted out, removed from the land and finally bed should be leveled properly for plantation
- A total of 20 ton/ha decomposed cow dung should be applied during final land preparation
- Crops namely Stem Amaranth, Red Amaranth, Brinjal, Chilli, and Okra should be seeded/transplanted in association with 60 days old Moringa saplings
- Appropriate intercultural operations should be done as and when necessary to obtain optimum plant growth.

Benefit of the Technology

- Vegetables could be grown in association with Moringa planting materials in the early stage of establishment
- Stem Amaranth, Red Amaranth, Brinjal, Chilli, and Okra could successfully be grown up to six months in association with Moringa without significant yield loss(2 to 6 % only) compared to control treatment
- Farmer can cultivate Moringa tree in association with vegetables maintaining 18 inches (45 cm) apart from the tree base without much yield loss.

Researcher:

Dr. Md. Kausar Hossain
Professor, Department of Agro-forestry & Environmental Science
Sher-e-Bangla Agricultural University, Dhaka
Mobile: 01701-777941, Email: kasuarsau@gmail.com

Agar-based Agro-forestry System in Sylhet Region

Introduction

Several traditional agro-forestry systems such as homestead based system, palmyra palm (*Borassus flabellifer*) and date palm (*Phoenix sylvestris*) based system, mango (*Mangifera indica*) based system, jackfruit (*Artocarpus heterophyllus*) based system, babla (*Acacia nilotica*) based system and sissoo (*Dalbergia sissoo*) based system etc. are familiar in the various agro-ecosystems of Bangladesh. These traditional agro-forestry systems have been improving the livelihood of the growers in Bangladesh by providing diversified products and services. In addition, agar (*Aquilariama laccensis*) based agro-forestry system also could be an interesting way of transforming a vast area of solitary agar garden in the north-eastern part of Bangladesh for year round production. Although agar wood produced from agar plant is a high value non-timber forest product, the agar plant requires very long time for paying back to farmers. Agar based agro-forestry system could be a good model of integration forest resources and high value crops in the form of a sustainable and flexible system.

Description of the Technology

- Introduction of tea *(Camellia sinensis)*, ginger *(Zingiber officinale)*, pineapple *(Ananas comosus)*, bilatidhonia *(Eryngium foetidum)* as associated crops in existing solitary agar garden is recommended for provisioning year round return in a sustainable manner
- Planting time of said compatible associated crops is April-May
- Climate-smart zero and/or minimum tillage and contour planting technology need to be practiced especially in slope
- Fertilizers and manure should be applied as per recommendation of Fertilizer Recommendation Guide, 2018
- Intercultural operations and pest management should be performed as and when necessary
- Suitable areas would be the medium plain to high land of Sylhet region.

Benefit of the Technology

- Year round return from agar garden could be obtained through introduction of compatible associated crops
- Farmers could be motivated by the agar based agro-forestry technology and agar garden could be increased
- Cropping intensity in Sylhet region could be increased
- Tea, ginger, pineapple, bilatidhonia could be grown in agar garden as agro-forestry technology instead of growing agar tree in a solitary for obtaining higher income.

Researcher:

Mohammad Samiul Ahsan Talucder
Assistant Professor
Department of Agro-forestry an Environmental Science
Sylhet Agricultural University, Sylhet
Mobile: 01711-974124, Email: samiulsau@gmail.com

Fisheries Technologies

Productivity Enhancement of Coastal Ghers through Year Round Shrimp-Tilapia Alternate Culture

Introduction

Shrimp aquaculture industry in Bangladesh is running with some major hurdles of disease outbreak and pollution of culture water due to lack of proper water management system in coastal Ghers causes poor production not exceeding 200 kg/ha. As a result about 217000 ha of the coastal Shrimp Ghers remain under-utilized. Sometimes the Shrimp farmers become penniless due to outbreak of disease and therefore looking for scientific and technological intervention for increasing per unit production than traditional farming. Under these circumstances, periodic culture of Shrimp with finfish in rotational basis with little interventions of feeding and water management would save the Shrimp from disease outbreaks and might promote per unit production and total farm out puts as well.

Description of the Technology

- Shrimp – Tilapia alternate culture is recommended for productivity enhancement of coastal Ghers
- Shrimp to be cultured during high salinity (5-18ppt) with 5 PL/m2 for 60 days, feeding@10-4% of body weight; followed by Tilapia farming during low salinity (0-5ppt) with 4 individual /m^2 for 90 days and 120 days incorporating crop rotation and diversification technique
- Pond preparation: Shrimp ponds are to be drained and re-excavated to remove bottom sludge, renovated dykes and sun dried for 7-10 days to eliminate toxic gases. Shrimp post larvae (PL) to be nursed inside the grow-out pond, where 10% area of each pond to be enclosed with nylon net. The entire pond areas are to be fenced as well using blue net to prevent the entry of disease carrier organisms. Liming to be done (Quick lime : dolomite 2:1) @250 kg/ha and should be filled with tidal water filtering by small mesh net up to 1m depth, treated with bleaching powder @60ppm to kill all animalcules. Then organic fertilizers such as fermented mixtures of molasses, rice bran and yeast (140:35:60Kg/ha) to be spread in ponds. After 2-3 days, oil-cake applied in liquid state @60 kg/ha and fertilized with urea and TSP @(25 and 30Kg/ha) for quick development of plankton
- Stocking Shrimp and post stock management: Specific Pathogen Free (SPF) Shrimp PL are to be collected and nursed inside ponds, fed nursery feed for 10-15 days and finally released to the whole ponds. Juveniles are to be fed grow out feed
- Stocking Tilapia: After harvesting Shrimp, ponds to be prepared as per standard method and healthy Tilapia fingerlings to be stocked in ponds, fed with commercial floating feed (10-3% of body weight) for 90 or 120 days
- Growth of fish and water quality need to be monitored at every 7 days interval
- Suitable areas would be the coastal Ghers of Bangladesh.

Benefit of the Technology

- Shrimp culture (60days): Higher average body weight, production, net benefit and benefit cost ratio (BCR) could be 17-18g, 734-797 kg/ha/crop, 83560 - 122134 BDT and 1.39 - 1.58 respectively
- Tilapia culture (90 days): Higher average body weight, production, net benefit and benefit cost ratio (BCR) of Tilapia could be obtained 146-152g, 4672-5400 kg/ha/crop, 29180 - 76435 BDT and 1.08 -1.20 respectively
- Tilapia culture (120 days): The highest average body weight, production, net benefit and benefit
- cost ratio (BCR) of Tilapia could be achieved as 180-218g, 5696-6105 kg/ha/crop, 146800-165900 BDT and 1.32-1.35 respectively.
- Short cycle Shrimp culture helps the crop to bypass the disease prone season and save the farmers from crop loss. Enhances total biomass production and resilience.

Researcher:

Syed Lutfor Rahman
Chief Scientific Officer
Bangladesh Fisheries Research Institute
Brackishwater Station, Paikgacha, Khulna- 9280, Bangladesh
Hand phone: 01715-938266, E-mail: rahman397@gmail.com

Culture of Short Cycle High Valued Fish Species in the Drought Prone Semiarid Zone of Bangladesh

Introduction

The Northern region of Bangladesh is known as drought and river bank erosion prone zone. Most of the districts (Rangpur & Dinajpur) of this zone experiences frequent natural disasters and adverse effects of climatic changes and surface waters almost disappear from ponds and canals, even major rivers having reduced water volume for 6-8 months. As a result the number of seasonal waters is increasing and about 55% ponds are seasonal of which 60% retained water for 4-6 months while 40% retained for 6 to 9 months in a year and even more in some areas. These small water bodies are being used mainly for household activities but some are still abandoned due to their derelict and marshy nature. In this semi-arid zone, fish farmers are lacking appropriate fish culture techniques as a result most of the farmers practice traditional way of fish culture. In this context, to ensure proper utilization of seasonal ponds, the culture of short-cycle valuable fish species could be introduced in the semiarid zone for enhancing fish production.

Description of the Technology

- Poly culture of short cycle valuable fish is recommended in the semiarid zone of Bangladesh for enhancing fish production and to improve farmers livelihood
- Adoption of Shing and Tengra poly culture using high valued short cycle fish species in semiarid zone of northern Bangladesh with combinations: (a) Shing 500 + Pabda 100 + Rajputi 10 + GIFT Tilapia 5 individuals/decimal, and (b) Tengra 500 + Magur 100 + Rajpunti 10 + GIFT Tilapia 5 individuals/decimal are recommended for enhancing fish production per unit area and time in a sustainable way
- Appropriate culture period would be April to August (5 months) and overwintered fingerlings (7-10cm) could be the key to successful fish culture in seasonal ponds
- Prior to stocking, ponds are to be dewatered and dried, aquatic weeds to be removed. Undesirable fish species to be removed by applying rotenone 25-35 gram/decimal/30 cm water, if necessary ponds are to be limed @1 kg/decimal. After 5 days of liming, cow-dung 6 kg dec^{-1}, urea 100 g dec^{-1} and TSP 75 g dec^{-1} to be applied at the initial stage during pond preparation
- Commercially available fish feed (30-35% protein) to be fed @ 10-5% of body weight per day
- Growth of fish and water quality need to be monitored at every 7 days interval
- Drought prone semi arid zone would be the suitable area.

Benefit of the Technology

- Poly culture of Tengra and Shing in seasonal waters at the semi-arid zone are economically viable
- Higher production of Shing poly culture – 5,351 to 5,828 Kg/ha, and Tengra polyculture – 2,240 to 2,252kg/ha could be obtained from seasonal ponds in the drought prone left fallow before,
- Higher Gross margin of Shing poly culture – (21,35,000 – 12,29,000 = 9,06,000 Tk/ha/crop) and Tengra poly culture – (16,65,400 – 10,12,000 = 6,53,400 Tk/ha/crop) could be obtained in farmers' ponds over the existing culture practice

Researcher:

Dr. Khondaker Rashidul Hasan
Principal Scientific Officer
BFRI, FSS, Saidpur, Nilphamari
Cell: 01714337502, Email: rashidulbfri@yahoo.com

Mixed Culture of Golda and Native Catfish in South-western Coastal Ghers

Introduction

Bangladesh is considered to be the most suitable country in the world for giant freshwater Prawn (M. rosenbergii) farming due to its fertile land and agro-climatic conditions. Prawn culture is socially more acceptable and technically and economically more viable and sustainable. On the other hand, Shing (H. fossilis) fish was abundantly available in open water system of floodplains, canals, beel and haors of Bangladesh. But due to over exploitation and ecological changes in its natural habitats, this species has become threatened. Indiscriminate destructive practices have caused havoc to aquatic bio-diversity in Bangladesh. Currently, Shing and Magur are the threatened fish in Bangladesh, but more demandable and that's why profit can be obtained by their culture. They can be cultured in any types of water body even in low saline water and can survive in adverse environment such as low dissolved oxygen, high water temperature, low salinity and even in polluted water. Therefore, high Golda can be successfully cultured with Shing and Magur in the south western coastal ghers with reduced water level and low salinity.

Description of the Technology

- **Pond/Gher preparation:** Embankment of gher/ponds to be repaired and elevated enough to prevent prawn/fish from escaping the gher/ponds and entry of unwanted fish, insect, vector of disease etc. into the gher/ pond. Gher/ ponds should be sun dried, ploughed and limed @ 250 kg/ha. After five days of liming, gher/ponds are to be fertilized with mohua oil cake (MOC), urea, TSP and MP @ 150 kg, 75kg, 45kg and 30kg/ ha.m. After filling up with rain water, gher/ponds should be fertilized with organic fertilizers such as rice bran, molasses and yeast @ 50 kg, 25 kg and 250 tea spoonful's/ha respectively
- **Stocking of prawn and fish:** Healthy juveniles of Prawn, Shing and Magur are to be stocked 30 individuals/decimal, 400 individual/decimal and 100 individuals/decimal respectively with prior acclimatization
- Feed management: The amount of feed to be adjusted fortnightly on the basis of sampling. Floating nursery feed (Protein 32%, Lipid 7%, Moisture7%), floating oil coated grower (Protein 27%, Lipid 6%, Moisture 9%) and Prawn grower (Protein 30%, Lipid 7%, Moisture 7%) are suitable for mixed culture of Golda and native Catfish
- For Shing, feed to be applied @10% of body weight for 1st two weeks (floating pre-nursery 1.5mm), 8% for 2nd two weeks (floating pre-nursery 1.8mm), 7% for 3rd two weeks, 6% for 4th two weeks, and is reduced to 2% from the subsequent weeks.
- For Magur, commercial pellet feed to be applied @ 6 % of estimated fish biomass for first two weeks and thereafter to be reduced to 4- 2% from the subsequent weeks up to 12th two weeks.
- Prawn juveniles to be fed @6.0 - 6.5 % of their body weight (around 2g) for the first two weeks, 5.5% for 3rd two weeks, 4.5 % for 4th two weeks, 3.8 % for 5th two weeks, 3.5 % for 6th two weeks, 3.2 % for 7th two weeks, and thereafter to be reduced to 2.5% from the subsequent weeks up to 12th two weeks.
- During culture period, gher/ponds should be fertilized with urea and TSP (1:2) at the rate of 40kg/ha and limed at the rate of 125 kg/ha to maintain pH and water qualities until harvesting.

Benefit of the Technology

- Higher production of Shing (350- 400kg/ha), Magur (200-250Kg/ha) and Golda (500-550kg/ha) could be achieved with benefit-cost ratio1.4
- Prawn for being resistant to white spot Syndrome virus can substitute shrimp which is highly susceptible to the same viral disease causes huge mortality and crop failure
- Coastal water bodies such as ponds, ghers, rice fields etc. with reduced water level, low/no salinity could be utilized for higher economic growth.

Researcher

Dr. Khan Kamal Uddin Ahmed
Chief Scientific Officer
Shrimp Research Station, BFRI, Bagerhat-9300
Mobile: +8801712103281 Email: kkuabd@yahoo.comkkuabd@gmail.com

Hygroryza aristata: A Floating Grass Utilized as Fish Feed is a New Initiative for Sustainable Aquaculture

Introduction

Vast tidally low-lying agriculture lands of Barishal, Pirojpur, Gopalgonj, Faridpur and Patuakhali districts contain 1.5–2.0 m deep water in the rainy season which can suitably be used for commercial aquaculture where the aquatic floating grass, Hygroryza aristata may be readily used as fish feed as well as substrate and hiding place for insects, crustaceans, zooplanktons and mollusks; and provides food for many species. H. aristata is a fast growing floating grass having spongy long stem with feathery whorled roots at nodes having 15.48 ± 0.22% crude protein, grows naturally in the tidally inundated low-lying agriculture land after rice production between February and November. The grass is preferred by some fish species such as grass carp as their main food. Both herbivorous and omnivorous fish like Grass carp, Common carp, Black carp and Tilapia could be cultured in the plant crawling area to graze on the plants advantageous for easy food availability, higher nutritional contents and cost-effectiveness. Since the global fishmeal price has increased more than two fold in recent years, the floating grass can be used as fish feed directly as in natural condition and thus cut down the feed cost. Coastal farmers may adopt this technology for greater economic benefit in their unutilized inundated low-lying wetlands to enhance their socio-economic condition.

Description of the Technology

- **Selection and preparation of culture area:** Culture area to be set-up in the inundated low-lying wetlands/agriculture land where 2-3 sides to be closed by dykes and the other 1-2 sides to be kept open to exchange water by tidal action. The open sides to be closed using mats made of bamboo splits and knotless net in such a way that tidal water can pass through the mats but not the stocked fish. All undesirable aquatic weeds to be removed from the culture area at the beginning. Bottom soil to be excavated to increase the depth of bottom (existing channel near to dyke) and this soil may be used to increase the height of the existing dyke as much as possible. On the bottom, approximately 2.5-3.0 m wide and 0.5-0.6 m deep channel to be created (if necessary) in the culture area to hold water during ebb tide on each day and in winter
- **Plantation of H. aristata:** The floating grass to be planted on bottom soil covering approximately 80-90% of the total culture area. During plantation, 15-30 cm long anterior portion of floating grass to be used as seedlings and 3-4 pieces are planted together while column and row are maintained like paddy plantation (25 to 30 cm distance)
- **Stocking of fish:** After 3-4 months of H. aristata plantation, healthy fingerlings of Grass carp (Ctenopharyngodon idella) (50-60g), Common carp (Cyprinus carpio) (25-30g) and Tilapia (Oreochromis niloticus) (25-30g) to be stocked at the ratio of 6:1:2 with a density of 11,100 individuals/ha and reared for twelve months.

Benefit of the Technology

- This fish culture technology is totally based on natural feed, where Grass carp directly consume the floating grass; Common carp prefer to eat insects, crustaceans, zooplanktons, benthic worms etc.; Black carp prefer snails but also feed on insects, shrimps etc. and Tilapia consume zooplankton, benthos, detritus, phytoplankton etc. for being omnivorous in nature and thus ensured enough natural food grown inside the culture area for fish species under cultivation
- Total fish production, production cost, net benefit and benefit cost ratio (BCR) could be achieved 9000kg/ha/year, 318000 BDT/ha/year, 15,20,000 BDT/ha/year and 4.78 respectively
- Poor farmers can afford this technology due to zero feed cost.

Researcher

Md. Moazzem Hossain
Associate Professor, Department of Fisheries Management
PSTU, Dumki, Patuakhali
Mobile: 01627-238105, Email: moazzem@pstu.ac.bd

Captive Culture of Seabass in the Coastal Brackish and Freshwater of Bangladesh

Introduction

Asian Seabass (Lates calcarifer),locally known as Koralmach a popular edible marine fin fish, commands consistent demand in domestic and international markets. Having the characteristics of catadromous pattern of life cycle, it's population occupies a wide range of habitats starting from freshwater rivers, estuaries and inshore coastal waters. Therefore, it can be cultured in a variety of culture systems using marine water, brackish water and freshwater. Although Seabass is a popular and high valued fish in Bangladesh and an ideal candidate for marine and coastal aquaculture, the breeding and culture techniques yet to be developed. At present culture of Seabass is being practiced with Tilapia where Tilapia fry is used as Seabass food.

Description of the Technology

- Polyculture of Seabass with Tilapia in brackish and freshwater earthen ponds where Tilapia is nourished with both supplementary & natural feed, and Seabass feed on Tilapia fry
- **Pond preparation:** Ponds to be dried and renovated with respect to dykes, depth, slope, bottom elevation, water supply and drainage facilities. Then ponds to be limed @1 kg/decimal and filled with water up to 1.2 m. After 7 days of liming, inorganic fertilizers to be applied @200 g urea and 100 g TSP /decimal pond area
- **Stocking of Seabass and Tilapia:** After 3 to 5 days of fertilization when the water colour turns green, ponds are to be stocked with adult GIFT Tilapia (Oreochromis niloticus; female: male=3:1) of size range160 to 166 g @80individual/decimal. After two weeks of stocking, Tilapia start to recruit it's new generation. Then, the fingerlings of Seabass (60-70g) are to be stocked @ 20 individuals/decimal. The ratio of Tilapia: Seabass should be maintained at 4:1.
- **Feed and feeding of Seabass and Tilapia:** The feed in the form of forage fish (Tilapia fry) is to be produced in the culture ponds itself and should be made available to the Seabass to prey on as and when it required. Natural feed productions in the ponds are enhanced by applying fertilizers (both organic and inorganic). Artificial floating feed (with 30% protein)to be supplied to Tilapia to ensure higher growth and breeding performance.

Benefit of the Technology

- After 330 days of culture, the average final body weight and net production of Seabass might achieve 587-592g and 1420-1508 kg/ha respectively. The average final body weight and net production of Tilapia could be 549-584 g and 6629-6896 kg/ha, respectively. Expected net benefit and benefit cost ratio(BCR) of this culture technique is 349394-471968 BDT and 1.30-1.41, respectively
- High valued Seabass could be cultured at the cost of low priced Tilapia fry.

Researcher

Dr. Muhammad Abdur Razzak
Assistant Professor
Department of Marine Fisheries and Oceanography
PSTU, Dumki, Patuakhali
Mobile: 01717-786424, Email: razzak408@yahoo.com

Breeding and Larval Rearing Technique of Gutum *(Lepidocephalichthys guntea)*

Introduction

Lepidocephalichthys guntea is a small indigenous species and locally known as Gutum or Puiya. This species is found in fresh and brackish water all over Bangladesh. Gutum is a scavenger and cleans up organic debris from the ecosystem. Currently the species is not as common as it was before. Siltation and drying of habitats and indiscriminate fishing of ponds, beels and ditches have reduced the stock of this fish. This species is found in small quantities with other species in the market especially in the rainy season. Sufficient number of fry and fingerlings of the species are quite difficult to obtain from natural waters for stocking in ponds. Proper techniques of induced breeding and large scale production of fry could be the most crucial factors in expanding culture practice and protecting the species from extinction.

Description of the Technology

- **Brood pond preparation, stocking and rearing:** Predators and unwanted fish are to be eradicated by dewatering and drying. Rotenone is to be applied in order to kill undesirable fish species and other aquatic organisms. Aquatic vegetation is to be removed manually. Ponds having 10-15 decimal area and 1.2 – 1.5 m depth could be used for rearing brood fish. Healthy and sexually mature male and female broods to be identified based on secondary sexual characteristics. Brood fish can be stocked with Indian major carp (IMC) or common carps or individually. The brood stock with the IMC or common carps is to be stocked @ 80-100/decimal and for monoculture @ 200-250/ decimal. Individually, Gutum broods are to be fed supplementary feed (fish meal 30%, meat and bone meal 10%, mustard oil cake 15%, rice bran 20%, soybean oil cake 20%, wheat flour 4%, vitamin and minerals 1%) @ 2-3% of body weight. But application of additional feed may not be necessary for rearing Gutum brood along with IMC or common carps
- **Sex and breeding season:** The mature males can be identified by their flat abdomens and long protruded genital papillae. On the other hand, the females can be easily recognized by their soft and swollen abdomen and round and swollen urogenital papillae. Breeding season ranges from April to July
- **Hormone protocol for induced breeding:** Carp pituitary gland (CPG) and ovaprim to be applied for female X male @ 10-12 mg PG/kg BW X 5-6 mg PG/kg BW and 0.8- 1.0 ml Ovaprim /kg BW X 0.4-0.5 ml/kg BW respectively
- **Types of incubator:** Glass jar incubator or Aluminum cistern incubator can be used for induced breeding of this species. Glass jar aquarium (0.7m×0.7m×0.7m) with exchange facilities @ 500 ml water/minute. Aluminum cistern incubator (1mX1mX1m) with water flow @ 100 L/hour is to be used. Around 6-8 pairs and 18-22 pairs of brood fish to be released in the glass jar aquarium and aluminum cistern incubator at a time for one cycle
- **Fry rearing in hapa:** Two and a half days old larvae are to be transferred into hapa. Only boiled yolk sac to be supplied to the larvae for first seven days and then provided supplementary feed powder contains minimum 30% protein @ 8% BW with three feeding frequency. Water quality and natural plankton density of hapa are to be monitored and maintained as per requirement. For protection of larvae, water hyacinths can be used as shelter in hapa.

Benefit of the Technology

- **Production:** The breeding and larval rearing technique of Gutum care economically viable. In glass jar Aquaria: 6-8 pairs brood could produce 1400- 1900 larvae per cycle and In Aluminum cistern: 18-22 pairs brood produces 50000-60000 larvae per cycle
- **Livelihood:** Immediate availability of fry of this fish could create a new horizon for economic activities of aquarium fish traders in rural and urban areas. Through viable nursery and rearing technique, fish farmers can be able to produce table size fish economically.

Researcher

Dr. Shyamal Kumar Paul
Assistant Professor
Department of Fisheries and Marine Science
NSTU, Noakhali
Mobile: 01716-024079, Email: shyamal@nstu,edu.bd

Culture of Nutrient Rich Live Feed (Microalgae) for Larvae of Brackish Water Fish

Introduction

Live feed is the most fundamental source of food and nutrition for successful seed production of commercially important fishes, mollusks and crustaceans. Brackishwater and marine hatcheries rely on live feed as the main source of food for larvae. As a result, the culture and production of adequate nutritive live food organism is considered as the heart of brackish water and marine hatcheries for sustainable seed production. However, production of available nutritive live feed is a challenge for the operation of hatchery in a sustainable manner. Live feed such as Nannochloropsis sp.,Nannochlorum sp. and Tetraselmis sp. are rich in essential fatty acids compared to other marine algae. The rotifer Brachionus sp. is an ideal feed item for brackish water fin fish and mud crab larvae due to suitable size and digestibility. However, live feeds are needed to be enriched to enhance the qualitative and quantitative nutrients, especially in terms of highly essential fatty acids (HUFA).

Description of the Technology

- Promotion of qualitative and quantitative live feed culture protocol could be sustainable for brackish/ marine hatchery and nursery operations through uninterrupted supply of larval feeds for mass seed production of fish and crustacean species
- Live feed microalgae (*Nannochloropsis* sp, *Nannochlorum* sp and *Tetraselmis* sp) species could be cultured under indoor and outdoor condition using F_2 media (standard algae culture media) and inorganic fertilizer
- For indoor and outdoor culture condition, 1ml F_2 medium/L of filtered seawater (25-30 ppt) to be inoculated with microalgae (0.5×106/ml) @ 5-10% of total culture medium. Light intensity to be maintained from 1500 to 2000 Lux for 24 hours at a constant temperature of 20-25 °C for 6- 16 days
- For mass culture, microalgae to be inoculated (0.5×106/ml) @ 10-30% of total culture medium in 300L of 25-30 ppt salt water enriched with inorganic fertilizer (N+P+K= 6g+0.5g+6g), to be cultured for 5-16 days under day-light photoperiod condition
- The rotifer, (Brachionusplicatilis) could be scaled up under outdoor condition in 300 liter plastic jars with an inoculum density of 20 ind./ml, yield 190 ind/ml in yeast + microalgae media in 10 days of culture period. But, increased inoculation density @ 300-400ind/ml might yield upto 750ind/ml of water using similar protocol. Rotifers are to be fed with baker's yeast 0.5-1 g/millions of rotifers/day.

Benefit of the Technology

- In 2 liter conical flask in indoor culture condition with F_2 medium and inoculums density 0.5×106/ml the highest average growth could be 6.91 cells/ml×106 for Tetraselmis sp. on 14th days of culture
- In 60 liter white container in outdoor culture condition with inoculums density 0.5×106/ml the highest average growth could be 3.31 cells/ ml×106 observed for Nannochloropsis sp. on 14th days of culture
- In 300 liter white fibre glass tank in outdoor culture condition with inoculums density 0.5×106/ml the highest average growth could be 3.57cells/ml×106 observed for Nannochlorum sp. on 14th days of culture
- Tetraselmis sp. contained highest protein content (63%) after 14th days of culture
- Enriched Rotifer (Brachionusplicatilis) with microalgae+ fish oil contains high protein content (68.4%)
- Live feed enhances survivability of shrimp/fish larvae, which might promote brackish and fresh water shrimp/prawn/finfish culture in Bangladesh.

Researcher:

Nilufa Begum
Senior Scientific Officer
Brachishwater Station
BFRI, Paikgacha, Khulna
Mobile: 01717-337725, Email: bfri.fpss@yahoo.com

Production Enhancement of Carps and Tilapia in Creeks of Chittagong Hill Districts

Introduction

The area of the Chittagong Hill Tracts is about 13,295 km2, which is approximately one-tenth of the total area of Bangladesh. Topographically, the Chittagong Hill Tracts are the hilly areas in Bangladesh. The depression of hilly slope connected with the main Lake or its stream and become inundated with enormous hilly streams during monsoon is called the creek. Three sides of arms of the creeks are surrounded by hilly land while the rest remain directly linked with the main body of the Lake or not. There are 4727 creeks covering 4297 ha areas of Chittagong Hill Tracts (CHT) among them 1200 creeks are adjacent to the Kaptai Lake having tremendous aquaculture prospects. The fish production capacity of these creeks is 2100 kg/ha that is eight to nine times more than the Kaptai Lake. The annual fish production of Chittagong Hill Tracts is 14773.46 MT including culture and capture which is significantly lower than the total annual inland capture of the country. In this context, to ensure maximum utilization of creeks, Carps & Tilapia polyculture technique could be practiced in the CHT area for enhancing fish production of Chittagong Hill Tracts.

Description of the Technology

- Culture of Carps and Tilapia in creeks of Chittagong Hill Tract districts with the combination of Rui14 + Catla 14 + Mrigal 12 +monosex Tilapia 20 individuals/decimal is recommended for enhancing fish production per unit area
- Culture period: February to November (10 months)
- Creek selection, preparation and stocking: Before stocking, creeks are to be selected on the basis of site location and communication, sufficient water retention capacity and water depth (01 to 05m). Creeks to be repaired including the mouth and unwanted sludge and vegetation to be removed from the creek bottom. Lime to be applied @250 kg/ha and fertilized with compost (mixture of chopped and sun dried green plants 88%, cow dung 10%, urea 1% and lime 1%)@ 1,250 kg/ha; urea @ 37.5 kg/ha and TSP @ 25 kg/ha. Then the creeks are to be left for10 days to promote algal development. After sufficient plankton grows, healthy overwintered fingerlings (7-10cm) are to be stocked with proper acclimatization
- Feeding: Commercially formulated feed (25-28% protein) to be supplied twice daily @ 10 to 5% of fish body weight through adjusting periodically in accordance with growth performance.

Benefit of the Technology

- Mixed culture of Carps & Tilapia in creeks can achieve an average fish production of 8200kg/ha/year with net benefit 4,80,000Tk/ ha/year, production cost 8,03,910Tk/ha/year and benefit cost ratio 1.59
- Enhance fish production and create livelihood improvement for the local disadvantaged community
- Create alternate income generation opportunity during the fish ban period in Kaptai lake, facilitate fish spawning and conserve biodiversity.

Researcher:

Md. Abul Bashar
Senior Scientific Officer
Riverine Sub-station, BFRI, Rangamati-4500
Mobile: 01717-671819; E-mail: mabashar.bfri@gmail.com

Livestock Technologies

Floating Bed Fodder Cultivation in Submerged and Flooded Areas

Introduction

Sylhet Division is consists of some hilly areas and hundreds of haors and beels varying in size from a few hectares to several thousand hectares. In monsoon these haor basins remain full of flood water but in winter remain dry and barren. As a result, especially during rainy and winter seasons, ruminants in those areas cannot get quality forage with the consequence of poor health and production. Floating bed agriculture is an age old practice of the farmers from Southern Bangladesh that evolved over the last 20 years. Use of such cultivation practice allows the farmers to cultivate crops against the obstacle of a disaster like flood. It is also cheap, easy and widely accepted by the local farmers and nowadays practiced in many parts of Bangladesh. Introduction of low cost floating bed fodder production and silage production technology may be an alternative to minimize the problems of fodder crisis in the haor areas.

Description of the Technology

- Floating bed fodder production is recommended for submerged and flooded areas as an alternative source of fodder materials to feed animals during lean period for increasing feed security for livestock in the haor areas
- Bamboo frame of the size of 9 – 18 m x 1.5 m (30-60ft x 5ft) need to be made and covered the frame with plastic net
- Four pieces of mature banana plants beneath/below the bamboo frame should be fixed for floating management. Empty plastic bottles may be used instead of banana plants
- For making the first layer of the floating bed, the floating bamboo frame need to be stacked with sufficient amount of dried water hyacinth to make at least one 30 cm (1 ft.) height. The top layer of floating bed should be prepared by adding dried cow dung mixed soil to the height of 7.5 cm (3 inches)
- After selecting a good location, the platforms should be fixed with bamboo poles keeping a suitable distance from the bank
- German grass (Echinochloa polystachya) would be suitable for floating bed fodder cultivation. Cuttings of German grass containing three complete internodes with four nodes should be planted in rows keeping row to row distance of about 25 cm with a plant to plant distance of 15 cm
- The grass could be harvested at 60 to 65 days for 1st cutting followed by 40 to 45 days for the subsequent cuttings
- To ensure year round availability of fodder, silage may be prepared using the floating bed grasses
- Submerged and flooded area would be suitable for this technology.

Benefit of the Technology

- Higher production of German grass could be obtained from floating bed (about 160 ton/ha) compared to floating bed Dal grasses (80 ton/ha) and naturally growing local grasses (18 ton/ha) and German grasses growing on land (85 ton/ha)
- Higher nutritional value of the silage of German grass would be obtained (Ash 4.88%, EE 3.93%, DM 30.5% and CP 12.37%) compared to the green German grass (Ash 3.5%, EE 3.49%, DM 16.7% and CP 10.15%)
- Silage also makes the fodder more digestible (IVD 45.66%) than the green grasses (IVD 36.56%)
- Floating bed fodder cultivation would not have any adverse effect on fish production
- Milk production of the cows fed with floating bed German grass would be increased by 0.2L/cow/day or 50L/cow/lactation along with the increase in fat composition (4.42%) which normally is 2.69%.
- Higher BCR (5.6) could be obtained for the cows fed with floating bed fodder compared to the cows fed with local grass (0.96).

Researcher:

Dr. Mohammad Mehedi Hasan Khan
Professor and Chairman
Department of Biochemistry and Chemistry
Faculty of Biotechnology and Genetic Engineering
Sylhet Agricultural University, Sylhet 3100
Mobile: 01680592166, Fax : +880821-761980, E-mail address: mehedi2001bdbd@gmail.com

Cost Effective Complete Pellet Feed for Commercial Goat and Sheep Production

Introduction

Goats and sheep represents the second important species of ruminant livestock and most popular in smallholder farmers of Bangladesh. They are usually grazed freely or tethered in natural and harvested fallow lands. With changing climatic and socio-economic conditions, presently there is little scope for free grazing of goats and sheep resulting in low productivity and poor reproduction of animals. Feeding system based on complete pellet feed is one of the promising methods for improving the utilization of poor quality crop-residues and agro industrial by products and this may help in developing stall-feeding methods for the commercial sheep and goat production as well as feed manufacturing entrepreneurs for the commercial production of complete pellet feed. This system of feeding also ensures the supply of balanced nutrients, reduces feed wastage, reduces feeding cost and maximizes production by converting poor quality, non-edible by-products into palatable and highly nutritious animal feed.

Description of the Technology

- A complete pellet feed prepared by using 40% roughage (Rice straw) and 60% concentrate mixture is recommended for commercial goat and sheep production
- Concentrate mixture would be prepared by taking Rice polish 50%, Maize crush 16%, Soybean meal 20%, Molasses 10%, Salt 2%, DCP 1%, Vitamin-mineral premix 0.5%, Pellet binder 0.5%
- To prepare complete pellet feed the roughage should be grinded first and then need to be mixed very well with the concentrate mixture at the ratio of 40:60
- Required amount of water and pellet binder should be added and mixed thoroughly which is then need to be passed through the pelleting machine for making pellets. The fresh pellets are then need to be sun dried and stored for animal feeding
- Goats and sheep should be fed Ad lib two times daily (9 am and 4 pm) with the complete pellet feed
- Pellet feed could be stored until 90 days.

Benefit of the Technology

- Pelleting enhances the efficiency of utilization of feed. For goats, daily body weight gain with the complete pellet feed could be achieved up to 52.46 g compared to the traditional semi-intensive feeding (17.76 g). Similarly for sheep, as against the daily body weight gain of 22.42 g, in traditional system of rearing, feeding with the developed complete pellet feed up to 100.67 g daily weight gain could be achieved
- For goats, considerably low FCR (5.7) could be achieved with pellet feeding compared to the animals with traditional feeding (8.32).
- Significantly ($p<0.05$) lower feed cost per kg weight gain (Tk. 124.22) could be achieved for goats with pellet feeding compared to the animals on traditional feeding (Tk. 214.74)
- For goats, higher BCR (1.93) could be achieved with pellet feeding compared to the animals under traditional feeding (1.16)
- In case of sheep however, no differences could be observed for the feed cost per kg weight gain, FCR and BCR among the pellet feeding and traditional feeding groups
- Complete pellet feed could be an alternative ready feed for commercial goat and sheep production under intensive or stall fed condition.

Researcher:

Dr. Sadek Ahmed
Senior Scientific Officer
Goat and Sheep Production Research Division
Bangladesh Livestock Research Institute, Savar, Dhaka-1341.
Cell: +8801712189212, E-mail: sadek_11@yahoo.com

Low Cost Technology for Making Processed Cheese

Introduction

Processed cheese (also named as prepared cheese, plastic cheese, or cheese singles) is a smooth, uniform cheese variety that is made by blending and melting together one or more rennet cheeses of different maturity or composition along with an emulsifying salt (such as disodium phosphate) and typically other ingredients (such as colourings, cream, water, or whey). Processed cheese is considered to be a safe product as the ingredients are cooked to a high temperature (usually 80-85°C) that kills almost all the microorganisms present in the ingredients. As low quality rennet cheese is used in manufacturing processed cheese, this makes the product relatively low priced one. Moreover, use of filler materials like skimmed milk, starch, etc. even reduces the price further. This type of cheese is widely used as single food as well as an ingredient in the bakery industry. Processed cheese is becoming increasingly popular in Bangladesh with the spread of fast food culture, changing food habit and increasing purchasing capacity of the consumers.

Description of the Technology

- With the minced rennet cheese (soft Dhaka cheese) of different degrees of maturity (25% Short ripened, 25% Medium ripened and 50% Long ripened) 3% emulsifying salt (75% tripolyphosphate, 5% sodium citrate, 15% sodium carbonate and 5% calcium chloride) and 3% table salt are to be added together along with potable water
- Other dairy (milk fat, milk protein, lactose, etc.) and non-dairy (potato starch, vegetable fat, vegetable protein, hydrocolloids, flavourings, sweetening agents, colours, preservatives, etc.) ingredients should be added for cost effectiveness, enhancing taste, textures and shelf life
- The ingredients are then to be mixed at 100 rpm using a centrifuge machine for 3-8 minutes
- During mixing, a minute amount of critic acid is to be added to adjust the pH of the final product to approximately 5.7 followed by continuous mixing under high heat (80-95°C) for 5-15 minutes
- The final product is then to be packaged and rapidly cooled to 4°C and stored at 18 to 20°C.

Benefit of the Technology

- It is estimated that around 8,000 tons of processed cheese is imported annually worth BDT 240 million. Processed cheese made with local ingredients reduces cost to a breakeven point that gives a profitable margin
- While the average wholesale price of processed cheese in the market ranges from Tk. 680 to 990 per kg, the blends thus prepared would cost around Tk. 525 per kg only including wholesale profit and distribution costs. Thus, the developed processed cheese would be 25-30% less costly as compared to the processed cheese currently sold in the markets of Dhaka and Chittagong/Chattogram city.

Researcher

Professor Dr. Raihan Habib
Department of Dairy Science
Faculty of Animal Husbandry
Bangladesh Agricultural University
Mymensingh-2202
Phone: +88 01712647823
E-mail: raihanh46@yahoo.com

Suitable Estrus Synchronization Protocol for Treating An-estrus Cows

Introduction

The reproductive performance of cows with high genetic merit declines in many dairy industries in Bangladesh due to low pregnancy rate in cows. An-estrus is one of the major causes of low pregnancy rate in cows. An-estrus not only does lengthen the postpartum interval, but also substantially reduce the farmer's financial returns from milk or beef sales. Various combinations of synthetic hormones are being used for treating an-estrus cows but with variable responses. Generally, estrus synchronization techniques can induce 75 to 90% of the cycling animals to display estrus within 5 days period. Additionally, many techniques can induce a fertile heat in as much as 50% of the anestrous cows. The hormones prostaglandin and GnRH are widely used in several schemes of estrus synchronization and controlled breeding program. Under the present study, for synchronization of estrus, three types of hormones viz., prostaglandins F2α analogue ($PGF_2α$), gonadotropin releasing hormone (GnRH) and human chorionic gonadotropin (hCG) were used either singly or in combination with others under seven protocols. About 90% of the an-estrus cows came to estrus when $PGF_2α$–GnRH–$PGF_2α$ with fixed time AI treatment protocol was used followed by $PGF_2α$–$PGF_2α$ and PGF2α–$PGF_2α$–$PGF_2α$ with fixed time AI (85.0%) treatment protocol. Therefore, $PGF_2α$–GnRH–$PGF_2α$ with fixed time AI treatment protocol was selected to be the best treatment protocol for an-estrus cows although this protocol is expensive (Tk. 2,600.00) compared to $PGF_2α$–$PGF_2α$ protocol (Tk. 1,550.00).

Description of the Technology

$PGF_2α$–GnRH– $PGF_2α$ Technique:

- Treat the an-estrus cow with broad spectrum anthelmintics and vitamin as per recommended dose
- Administer, through intramuscular (i/m) route, the cows with PGF2α (Inj. Ovuprost, Renata, Animal health) at day 0
- After 12 days administer (i/m) the cows with GnRH (Inj. Ovurelin 5 ml, Renata Animal Health or Inj. Fetazyl 5 ml, Intervet limited)
- Then after 7 days, administer (i/m) the cows again with $PGF_2α$.
- Check the cows for estrus and inseminate (fixed time AI) the positive cows after 12-18 hours, along with GnRH injection.

Benefit of the Technology

- Estrus synchronization helps shortening calving periods and synchronizing calving season that in turn provides producers a better opportunity to offer improved management and observation of the cows' herd, which should result in fewer losses at calving
- Shortened calving periods also facilitates improvements in herd health management resulting in decreased labor requirements
- Another benefit is that cow nutrition can be improved by grouping cows according to stage of gestation and feeding each group accordingly.
- An additional benefit is that the calf crop will be more uniform in age and size which can lead to an advantage in the market place.
- Ultimately, the treatment protocol will help cows to come into heat within 60 days after last delivery and one calf per cow per year will be ensured which in turn will help increasing milk and calf crop productions.

Researcher

Dr. Md. Jalal Uddin Sarder
Professor, Department of Veterinary & Animal Science
University of Rajshahi, Rajshahi
Mobile: 01556-308564, Email: jalalnusa @ yahoo.com

Duck Diseases in Hakaluki and Tanguar Haor and Their Prevention Strategies

Introduction

Bangladesh has the third largest duck population (38.1 million) in the world. A significant number of ducks are reared in the swampy land areas (e.g. haor) that play a vital role in the livelihood of poor people. Infectious and non-infectious diseases in haor areas are considered one of the major constraints in duck rearing. Therefore, it is necessary to identify the prevalence of different infectious and non-infectious diseases in the domestic ducks of Hakaluki and Tanguar haor as well as recommends a compatible vaccination strategy for disease control and prevention.

Description of the Technology

- **Disease prevalence in ducks:** Ducks in the haor areas suffer from Gastrointestinal (GI) parasitic infections with Ascaridia spp, 4.72%; Capillaria spp, 17.83%; Prosthogonimus spp, 9.33%; Amidostomum spp, 11.33%; Tetrameres spp, 5.83% and Hymenolepis spp, 3.33% and blood protozoan diseases with Haemoproteus, 13.17%; Leucocytozoon, 8.33% and Plasmodium spp, 7.67% Among the viral diseases, the ducks in the haor areas suffer from Duck viral hepatitis (4%) and Duck viral enteritis (3.33%). Although there is no clinical symptoms, 90.5% of the ducks in the haor areas carry Avian influenza virus, which is an important information for policy makers to take into consideration when planning for the control of Avian influenza in the poultry population in Bangladesh Among the bacterial diseases, the ducks of the haor areas suffer from Escherichia coli (55.33%), Salmonella typhimurium (20.5%) and Staphylococcus aureus (44.1%) infection. It is documented for the first time in Bangladesh that the ducks in the haor areas are suffering from Duck septicemia also called New duck disease, caused by Riemerella anatipestifer, at a rate of 10%. The occurrence of Mycoplasma gallisepticum infection is 5.3% in the duck population of haor areas.
- **Disease control strategy in ducks:** Along with regular deworming of ducks at 4 months' interval, following vaccination schedule is recommended for the control of duck diseases in the haor areas:

Name of vaccines	Vaccination schedule
Duck plague	Compulsory vaccination at the interval of 6 months.
Duck cholera	Vaccination of ducks against circulating serotype, using the vaccine with local isolates.
Duck viral hepatitis	Vaccination only for breeder ducks (intensively reared for hatching eggs)
Avian influenza	Investigation should be conducted towards clinical form of AI in the ducks. Vaccination against AI is suggested in the commercial ducks
Salmonella	Regular vaccination is recommended
Riemerella anatipestifer	Vaccine should be developed using local isolates

Benefit of the Technology

- Adoption of the proposed vaccination schedule along with the regular deworming of ducks will hopefully reduce the occurrence of different diseases and mortality in the ducks; consequently production of ducks in terms of eggs and meat will be increased thereby increasing farm income.

Researcher

Dr. Md. Shafiqul Islam
Department of Pathology and Parasitology
CVASU, Chattogram
Mobile; 01670-517796, Email: si.mamun@ymail.com

Probiotic Food Products for Human and Feed Products for Poultry

Introduction

Probiotics refer to harmless live normal flora/microorganisms that provide a health benefit on the host, when administered in adequate amounts and it also leads to have nutritional advantages. Regular utilization of food containing probiotic microorganisms is recommended to build a positive balance of the population of useful or beneficial microbes in the intestine. Probiotic microorganisms such as Bifidobacterium and Lactobacillus strains found in gastrointestinal tract (GIT) and food supplements, is highly diverse, its composition and number also differs. The gut microbiota plays a critical role in up keeping human health. Probiotics are usually introduced to food, condiments and beverages as a component of fermentation process at appropriate stage. Native presumptive probiotic bacteria isolated from yogurts as well as from GIT of poultry could play a significant role in developing probiotic based food products for human and feed products for poultry and thereby exerting health beneficial effects as well as preventing the occurrence of several diseases.

Description of the Technology

Probiotic yogurt for human:

- Milk to be boiled at 100°C for 15 minutes and during boiling, Table sugar or sucrose to be added as per degree of sweetness
- Boiled milk is then to be cooled to 40°C and to be inoculated with 5% (v/v) liquid culture of Probiotic bacteria isolated from yogurt
- Inoculated milk to be poured into suitable yogurt making containers and to be incubated under anaerobic condition at 37° C for 8-12 hours
- After coagulation, fresh yogurt is ready to use or to be preserved at 4° C for further serving/usage.

Probiotic starter feed for poultry:

- Probiotic layer starter feed is to be prepared by using maize (60%), fish meal (10%), soybean meal (15%), wheat bran (12%), oyster shell (2%), vitamin/mineral premix 1% and broth of Probiotic bacteria 40-50 ml/kg of feed mixture
- Probiotic broiler starter feed is to be prepared by using maize (212 gm), wheat (270 gm), soybean meal (300 gm), fish meal (100 gm), wheat bran (50 gm), rice bran (50 gm), vitamin/mineral premix (8 gm), Digestible Crude Protein (10 gm) and Probiotics isolates 2-4x10^9CFU
- Probiotic duck starter feed is to be prepared using maize (51%), soybean meal (29%), fish meal (2%), wheat shorts (9.3%), chaffed straw (3.5%), talcum powder (1.2%), Dicalcium Phosphate (1.7%), NaCl (0.3%), Carrier (Bentonite) (1%), Premix (1%) and Probiotics isolates 2-4x10^9CFU.

Benefit of the Technology

- The probiotic bacteria could exert anti-hypercholesterolemic, anti-diabetic, anti-microbial, anti-diarrheal and anti-allergic effects if used in food and feed products
- Probiotic bacteria could increase the meat quality of poultry including duck and upgrade the quality of eggs if used in poultry/duck feed as feed supplements or additives
- Probiotic based human foods and poultry feeds could subsequently substitute the existing antibiotic based food and feed additives the potential threat for antimicrobial resistance.

Researcher

Dr. Khandoker Moazzem Hossain
Professor, Biotechnology and Genetic Engineering Discipline
Khulna University, Khulna
Mobile: 01711-381803, Email: kmhossainbt@yahoo.com.au

Suitable Long Bone Fracture Management in Animals

Introduction

Long bone fractures are very common in the pet and food animals in Bangladesh. Hind limbs are more affected than fore limbs. Metatarsal and metacarpal fractures are more common in calves, sheep and goats. Femur and tibial bone fractures are more common in dogs and cats. Long bone diaphyseal fractures are common in dogs and among them fractures of the shaft of tibia are the most common. Due to inadequate knowledge and proper management technique along with ignorance of proper postoperative care, every year a large number of pet animals have to go for amputation and food animals are advised for slaughter. External coaptation by using Modified Robert Jone's (MRJ) bandage technique is suitable for long bone fracture management especially for metacarpal, metatarsal, radial and tibial bone in dogs, cats and goats. This technology factsheet describes the easy, sustainable and economic long bone fracture management technique, the MRJ bandage technique in the animals in Bangladesh to reduce the complications of fractures and the culling rate of food and pet animals.

Description of the Technology

External fixation or MRJ bandage technique for long bone fracture managemen:

Materials required:

- Adhesive tape (size: 2.5-5.0 cm), number one; Cotton (size: 1 pound pack), number 1-2; Bandage roll (size: 7.5-12.5 cm), number 4-8; Elastic or pressure/Crepe Bandage (size: 7.5- 10.0 cm), number 1-2
- Using the cotton, 6-12 cotton rolls have to be prepared (Approximately 1cm thick, 7.5-12.5 cm wide and 45-75 cm long cotton layer to be prepared and rolled very loosely).

Preparation of the patient:

- The patient has to be laid on a table or clean floor with the affected limb upper position and gently held or controlled using sedative agents (diazepam- 0.5 mg/kg, i/v for goat and xylazine- 1.0 mg/kg, i/m for cats and dogs).

Management of fracture:

- After reduction or proper anatomical alignment of the fractured bone, the affected limb has to be wrapped liberally by the cotton roll in outward to inward fashion from toes/hoof to the midfemur or midhumerus up to the sufficient strength as an external support, with approximately 7.5-12.5cm thickness
- On the cotton padding, the bandage roll has to be applied with moderate pressure and then pressure/crepe bandage has to be applied with mild pressure
- Adhesive tape is then to be applied sufficiently in round and longitudinal fashion.

Care of the patient:

- The owner has to be advised to keep the patient in dry and clean place, to check the affected limb twice daily for any swelling or bad odor and complete rest for 1-2 week
- The bandage has to be removed after functional improvement of weight bearing, posture and gait (approximately after one month).

Benefit of the Technology

- External fixation technique of long bone fracture management is an easy technique compared to other techniques like, Internal fixation technique that require operation under general anesthesia
- Highly economic: External fixation technique requires minimum materials and consequently, it is cheaper (Tk. 470.00) than the Internal fixation technique (Tk. 1450.00)
- Good outcome: Response to treatment in the case of External fixation technique is higher (71.77%) than the Internal fixation technique (9.41%)
- Less complications: Post operative complications occur less (4.71%) in External fixation technique compared to Internal fixation technique (14.12%).

Researcher:

Dr. Bhajan Chandra Das
Professor, Department of Medicine and Surgery
CVASU, Khulshi, Chattogram
Mobile: 01930-370731, Email:bcdas2002@gmail.com

Formalin Killed Egg Drop Syndrome Vaccine Using Local Isolates

Introduction

Egg drop syndrome (EDS) is one of the most common barriers in poultry production especially in layer birds. The disease is caused by EDS-76 virus infection and is characterized by sudden drop in egg production and production of shell less or soft shelled eggs. The drop in egg production in layer birds has become a major concern in Bangladesh due to the enormous economic burden faced by the farmers. The loss incurred by poultry industry due to reduced productivity, culling and cost of medicine is considered to be often greater than loss due to mortality. Keeping the above mentioned problems in mind formalin killed EDS vaccine has been developed using local isolates of Egg drop syndrome virus.

Description of the Technology

- A 0.2 ml volume of locally isolated and characterized egg drop syndrome (EDS-76) virus suspension is inoculated into 11 days old duck embryos through allantoic cavity route followed by incubation at 370 C for 5 days.
- The allanto-amniotic fluid (AAF) is then harvested, pooled together and hemagglutination assay (HA) or EID50 titer determined.
- EDS-76 virus with HA titre of 12log2 or EID50 of log108.6 /ml is then inactivated with 0.12% formalin followed by safety and sterility test of the virus suspension.
- Formalin inactivated virus suspension is then adjuvanted using either ready to use oil emulsion Montanide or a mixture of paraffin, arlacil and tween-80.
- Birds of the age of 16 weeks could be vaccinated with the vaccine at a dose of 0.5 ml by intramuscular route.

Benefit of the Technology

- Egg production due to EDS-76 virus infection may decrease from 10 to 40% causing severe economic loss to the farm.
- Hygienic measures along with vaccination are the very effective tool for the prevention of EDS-76.
- All commercial vaccines available in Bangladesh are imported and prepared from foreign origin of virus isolates; consequently the vaccines are costly and exhaust hard earned foreign currency.
- Use of locally developed EDS virus vaccine hopefully will be of great value and enhance financial benefit for the poultry farms of Bangladesh.

Researcher:

Dr. Marzia Rahman
Professor
Department of Microbiology and Hygiene
Bangladesh Agricultural University, Mymensingh
Mobele: 01916-594452, E-mail: marzia_micro@yahoo.com

Manipulative Reproduction Technologies for Quick Genetic Improvement in Cattle

Introduction

Manipulative reproduction technology (MRT) has the potential to improve production, reproductive efficiency and rates of genetic improvement in livestock. MRT involves production of high quality sperm, estrus synchronization and timed artificial insemination (TAI). The technology thus involves semen processing, estrus synchronization and TAI at the farm level for the production of sex selective offspring to speed up the genetic improvement of economic traits of cattle. Using dextran swim-up fraction separation of whole semen 72.9% male and 85.4% female calves could be obtained from Fraction-1 and Fraction-4, respectively. The highest pregnancy (92.3%) and calving (89.7%) rates could be obtained through inseminating cows with frozen-thawed semen after oestrus synchronization with Co-synch protocol at commercial farms.

Description of the Technology

- Manipulative reproduction technology (MRT):

a) Swim up technique for production of sex selective offspring in cows

- Frozen-thawed semen to be placed beneath a dextran solution, the semen separation medium (SSM)
- Supernatants (Fractions) to be collected from the dextran solution for four times at 15 minutes interval
- Fraction 1 has to be used for male calf production and
- Fraction 4 has to be used for female calf production. Sperms with larger head width would produce more female calves.

b) Estrus synchronization

Co-SYNCH protocol for estrus synchronization to be used as follows:

- Selected cows has to be administered, using intramuscular (i/m) route, with GnRH (250 µg) at day 0
- EAZI-BREED CIDR (progesterone intravaginal insert) has to be inserted intravaginally at day 2
- CIDR has to be removed and PGF2α (500 µg) administered (i/m) at day 7
- GnRH (250 µg) to be administered (i/m) at day 9
- Timed AI using the fractionated semen (Fraction 1 or 4)to be done after 16-20 hours of 2nd GnRH injection
- Pregnancy diagnosis to be done after 35 days of AI.

Benefit of the Technology

- Sex ratio manipulation can sensibly enhance the effectiveness of selection and genetic improvement programs, through production of male or female offspring born after AI
- Large dairy or beef farms could use MRT to control and design the breeding plans for dairy cows (female calf) or beef cattle (male calf)
- Estrus synchronization helps shortening calving periods and synchronizing calving season that in turn will provide producers a better opportunity to offer improved management and observation of the cows' herd, which should result in fewer losses at calving
- Cow nutrition can be improved by grouping cows according to stage of gestation and feeding each group accordingly
- Calf crop will be more uniform in age and size which can lead to an advantage in the market place.

Researcher:

Dr. Nasrin Sultana Juyena
Professor, Department of Surgery and Obstetrics
Faculty of Veterinary Science
Bangladesh Agricultural University, Mymensingh-2200
Mobile: 01759-674267, Email: juyenahabib@gmail.com

Probiotic Feed Supplement for Calves

Introduction

Probiotics or microbial feed additives are defined as "live microorganisms which, when administered in adequate amounts, confer a health benefit on the host". Probiotics are potential alternative to antibiotic for increasing feed intake and weight gain, earlier weaning, increased immunity, decreased scours and fecal coliform count in calves. Microbial feed additives facilitate the establishment and maintenance of suitable microbial flora in the gastrointestinal tract. The early establishment of large amount of beneficial microorganisms in the gut helps to combat the negative effects of unfavorable conditions or prevent the pathogenic organisms. The most commonly used microbial additive is Lactobacillus spp. These microbes have specific roles in the host's body, primarily responsible for the exclusion of enterotoxigenic bacteria. Microbial feed additives used in ruminant feeds are mainly for stabilization of the intestinal flora, enhancing the development of the adult rumen microflora, improving digestion and nitrogen flow towards lower digestive tract, and improving meat and milk production. Probiotics administration improves the health status of the animal by competing with the nutrient utilization by the pathogenic microbes through having a positive influence on gut microflora. Furthermore, their anti-pathogenic activity may reduce the stress on animal. This technology factsheet describes the preparation of probiotic feed supplement for calves and its beneficial effect on calf health.

Description of the Technology

- Probiotic feed supplement is to be prepared using the ingredients wheat bran- 500g; molasses- 100g; water-300ml and 10 ml each of 6 log10 CFU/ml of LAB (*Lactic acid bacillus*, *L. acidophilus*), SC (*Saccharomyces cerevisiae*) and BS (Bacilus subtilis) culture
- All ingredients are to be autoclaved (excepting the microbial cultures) before mixing to kill existing organisms in the ingredients
- All the ingredients are then to be mixed together homogenously, packed and incubated at 37 C for 3 days
- During incubation, feeds are to be stirred 2 times daily for preventing clumps formation and facilitating vigorous fermentation
- After 3 days of incubation the feeds are to be harvested and evaluated for moisture, pH, viable count of each microbes, organic matter (OM), crude protein (CP) and ammonia-N content
- These feed under air-tight packed condition could be maintained with high number of probiotic microbes for at least 45 days.

Benefit of the Technology

- This probiotic feed supplement will helps in reducing coliform count but increasing probiotic bacteria count in the feces of calves
- This probiotic feed supplement will also helps in reducing diarrheal frequency and increasing immunoglobulin status in calves
- It is expected that this probiotic feed supplement will help in increasing feed intake, daily gain or feed conversion ratio (FCR) of calves thereby improving calf health.

Researcher:

Dr. Sardar Muhammad Amanullah
Senior Scientific Officer
Biotechnology Division
BLRI, Savar, Dhaka
Phone: 01913715335, E-mail: amanullah@blri.gov.bd

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