ISSN: 2582-6980

AGRI MIRROR FUTURE INDIA

AIASA Agriculture Magazine

A Voice for Agriculture

Issue 02 / 2023

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A Voice for Agriculture

AGRI MIRROR : FUTURE INDIA

Issue 02 | 2023

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EDITORIAL TEAM

AGRI MIRROR : FUTURE INDIA
ISSN: 2582-6980

Article ID: 248

DISEASES OF CARROT AND THEIR MANAGEMENT

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Introduction

Carrot (*Daucus carota* subsp. *sativus* (Hoffm.) is an economically important, most popular vegetable crop in the world. Roots are consumed both as a raw and a cooked vegetable. It is rich in carotene, a precursor of vitamin A and contains appreciable quantities of thiamine and riboflavin. The most abundant antioxidant compounds found in carrots are α- and β-carotene, vitamin E, and anthocyanin. Hence, they are believed to possess various health benefits including the potential to prevent cardiovascular disease and certain types of cancers. The crop is affected by various diseases including Alternaria leaf blight, white mold, powdery mildew, Cercospora leaf blight, bacterial soft rot and cavity spot. Their symptoms and management aspects were given hereunder.

White Mold (*Sclerotinia sclerotiorum*)

White mold is an economically important disease of carrot that can affect late in the growing season and during storage. The losses can be as high as 50% due to *sclerotinia* rot and secondary bacterial soft rot infections. This disease also called as cottony rot, watery soft rot, stem rot, drop, crown rot and blossom blight

Symptoms

Symptoms in the field appear as water-soaked, dark olive-green lesions appear on the foliage at the soil line, expand rapidly over the entire petiole, leaf and rosette with infected tissues. Aerial hyphae appear behind the advancing discolored lesion. Soon becoming covered by abundant cottony, white mycelium and black sclerotia on the crown and other infected parts. Reduce yield by weakening the tops and rendering mechanical harvest inefficient. In storage, lesions on carrot roots appear as a soft, watery rot with fluffy white mycelia and black sclerotia substantially affect shelf-life and marketable value of carrots.


Causal agent: *Sclerotinia sclerotiorum*

The fungus produces hyaline, septate and branched hyphae. Mycelium may appear fluffy white with black sclerotia (2 to 20 mm). The sclerotia germinate and give rise to cup-shaped structures called apothecia consist of ascus. Ascospores produced in the ascus discharge into the air and are carried by wind.

Survival and Spread:

The fungus produces hardy resistant survival structure called sclerotia. It can survive in soil for many years. Fungus spreads by transport of sclerotia along with contaminated soil or crop debris or irrigation water and by wind-borne ascospores.

Favourable conditions

Sclerotinia is most active when soil temperatures are 15° to 21°C. High soil moisture and a dense canopy are necessary for fungal activity.

Management

Adopt summer ploughing. Crop rotation with non-host crops such as cereals, corn, or cotton will also help reduce sclerotial populations in the soil. Avoid planting carrot into fields with a history of cottony soft rot. Apply green manure followed by soil application of *Trichoderma viride* (*T. asperellum*) 1 Kg / ac. Seed treatment with *T. viride,* 4 g / Kg. Improving ventilation within the crop canopy by effective weed control, increasing row-row spacing, growing on ridges or raised beds and/or cutting excess foliage. Provide rapid cooling of carrots prior to storage. A good sanitation in the field and storage is important to limit the disease spread.

Alternaria leaf blight: *Alternaria dauci*

Symptoms

Symptoms first appear on older leaves as greenish-brown, water-soaked lesions along leaflet margins. Later enlarge and turn brown to black, often develop a yellow halo. As the disease progresses infected leaflets become yellow, collapse, die and appear as if scorched by fire. Severe loss of foliage may occur. Petiole lesions are common, elongate, and can quickly kill entire leaves often results in reduced yields. This fungus also causes damping-off (pre emergence or post emergence) of seedlings.

Figure 1. Symptom development on petiole and leaves (Photo source: Kimberly Cochran)

Causal agent: *Alternaria dauci*

A. dauci produces characteristically dark to olive-brown, septate and branched mycelium. Conidia are usually solitary, long, ellipsoid-to-obclavate, dark olivaceous brown, with 5 - 11 transverse and 1 (rarely 2 - 3) longitudinal or oblique septa with filamentous beak. The conidiophores are olivaceous brown, simple or 1 - 2 geniculate.

Survival and Spread:

After crop harvest, the pathogen, *Alternaria dauci* can survive in seeds, plant debris and volunteer plants. This fungus remains in the pericarp as dormant mycelium and / or spores and on the surface of the seeds as spores. Primary spread of mycelium and spores through infected seed and seedlings, secondary spread through wind, splashing rain, tools or contaminated soils.

Favourable conditions:

Moderate to warm temperature (28°C), extended periods of leaf wetness due to rainfall, dew, or overhead irrigation. Overcrowding of plants

Management:

Adopt crop rotation for 3 – 4 years. Select disease resistant or tolerant cultivars. Treat the seeds by immersing in hot water at 50°C for 20 minutes or Seed treatment with the fungicide, Thiram (4g/kg of seed). Planting on raised beds with wider row spacing to avoid overcrowding of plants. Maintain weed free environment. Foliar spray with the fungicide, Copper Oxychloride (500 g /ac). After harvest, turn the carrot residues under the soil.

Powdery Mildew: *Erysiphe heraclei*

Ssymptoms:

White, powdery fungal growth can initially be found on the older leaves, petioles and stems which then spreads to the newer developing leaves. Infected foliage turns brown, brittle, twist, and die. Severe infection can result in loss of foliage, causing lower yields. In seed crops, infected pedicels may turn brown, causing the florets to die prematurely or may produce poor quality seeds.

Causal agent:

The fungus is considered an obligate biotroph. Mycelium amphigenous, mainly on the upper leaf surface with lobed appressoria. Conidia formed singly on the conidiophore, most subcylindric to cylindric. Fugus produces sexual fruiting body called cleistothecium which bears asci containing ascospores.

Survival and mode of spread:

The fungus survives on overwintered carrots and related weed hosts as cleistothecium. Primary spread is from ascospores from the infected debris. Secondary spread is through air borne conidia**.**

Favourable conditions:

High humidity during evening and morning hours, and dry conditions favours the disease. Temperatures between 13° and 32°C. Plants are more susceptible when growing in shady locations or stressed by drought.

Management

Plant tolerant or plant fast-growing varieties. Adapt crop rotation. Avoid using excessive nitrogen fertilizer. Prevent drought stress by providing ample fertilizer to support strong foliar growth, and mulching to conserve soil moisture. Provide ample water using a sprinkler or hose during the morning hours, which can wash powdery mildew spores from leaves.

Cercospora leaf blight: ***Cercospora carotae***

Symptoms

Foliar symptoms are amphigenous, subcircular with light brown center and dark brown border on the margins of leaflets often with a chlorotic halo. During humid weather, the lower surface lesions turn pale gray and are peppered with tiny black spore-producing structures. As the disease

develops, lesions increase in size and number, the entire leaflet curl, shrivel and die, creating a burnt appearance. Under heavy disease pressure, severe loss of foliage may occur. The lesions on the petioles are oval shaped with tan centres and brown borders. The petioles may be girdled, causing the leaves to die. When infection occurs later, the fungus commonly infect the flower and invades seed.

Cercospora leaf blight on carrot leaf

Causal agent:

The fungus produces branched, septate and gray mycelium. Conidiophores were simple and straight to subflexuous with a bulbous base. Conidia were solitary, cylindrical to narrowly-obclavate with 2 to 6 septa, and hyaline to subhyaline.

Survival and Spread:

Pathogen survives mainly in plant debris as desiccation-resistant pseudostromata, but can also survive as conidia in debris or seeds. Spreads by wind and rain splash conidia, farm machinery and workers.

Favourable conditions

A significant amount of disease occurs at temperatures from 20 to 30°C and a leaf wetness period longer than 12 hours.

Management

Adopt crop rotation.
Use pathogen free seeds
Select non infested seed bed
Seed treatment with captan 4g/kg
Maintain weed free environment.
After harvest, turn the carrot residue under the soil.
Follow balanced fertilization (Split application of N)
Spray mancozeb @ 400 g/ac or Copper oxychloride 500 g /ac

Cavity spot: *Pythium violae* and *Pythium sulcatum*

Symptoms

Cavity spot often shows up near harvest. It does not tend to reduce yield, however affect the marketability. Infections can take place anywhere along the root surface. Lesions start as pinhead-size sunken spots, become small elliptical, superficial cavities on taproot.

Cavity spot caused by *Pythium* sp., (Photo: S. Livingston)

Causal agent: *Pythium* spp.

The fungus produces hyaline, coenocytic hyphae, thick walled oospore, zoospore. However, most of their isolates not reported to be produce zoospores.

Survival and mode of spread

Pythium overwinters as resting mycelium or as resistant thick-walled oospores in soil. Primary spread through oospores and secondary spread by irrigation water.

Favourbale conditions

Cool and wet weather. Optimum temperature for cavity development is 15°C. Cavity spot severity is maximum at pH 5. Calcium Deficiency.

Management

Avoid fields with a recent history of cavity spot.

Crop rotation

Addition of lime at 6 t / ha can reduce the disease severity upto 50%

Plant carrots on raised beds in well-drained fields.

Avoid over fertilization

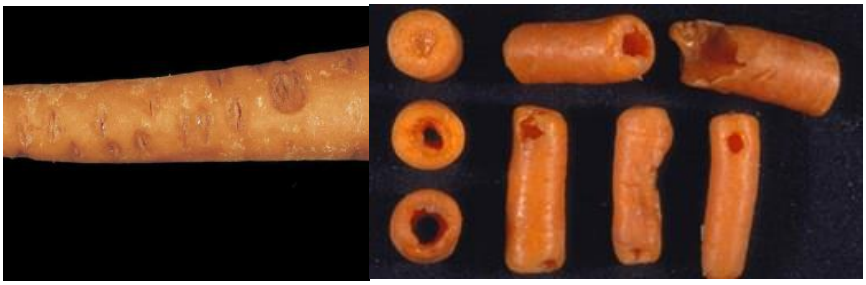
Harvest carrots soon after maturity.

Bacterial soft rot: *Pectobacterium carotovorum* subsp. *carotovorum* (syn. *Erwinia carotovora* subsp. *carotovora*)

It is a common disease of carrot, causes major losses in storage.

Symptoms

Bacterial soft rots of carrots occur only when soil conditions are wet or storage conditions are poor. Bacterial soft rot appears as small water-soaked lesions on any part of the carrot, although it is often associated with the eyes. Lesions become sunken, quickly enlarge and coalesce. That leads to soft, watery, and slimy decay of taproot. The decay rapidly consumes the core of the carrot, often leaving the epidermis intact. A foul odor may be associated with soft rot. When the macerated tissue is exposed to the air, it turns tan or gray. Aboveground symptoms include a general yellowing, wilting, and collapse of the foliage.



Causal agent: *Pectobacterium carotovorum* subsp. *carotovorum* (syn. *Erwinia carotovora* subsp. *carotovora*). The bacterium is gram-negative, rod shaped and motile with peritrichus flagella.

Survival and spread*:*

Erwinia spp. are common soil bacteria that survive on crop residues. In the field, disease spreads primarily by soil-borne inoculums, secondarily through irrigation and rain splash. During post harvest handling, these bacteria are readily spread in washing water.

Favourable conditions:

Disease becomes apparent under high soil temperature and moisture. Abundant moisture on the root surface favours disease. Soft rot bacteria enter carrots through wounds.

Control:

Planting on raised beds in poorly drained areas may reduce bacterial infections. Maintain good drainage in field. Use disease free healthy planting material. Harvest crops intended for long-term storage after soil and air temperatures drop. Minimize mechanical damage during harvest and after harvest. Root surface should kept dry and store them at 0°C and 85% to 90% relative humidity. Thoroughly clean and disinfect bins between storage seasons. Infected roots should not be stored along with the healthy roots, Roots can be rinsed with clean, chlorinated water before being placed in a refrigerated holding area.

AGRI MIRROR : FUTURE INDIA
ISSN: 2582-6980

Article ID: 249

UNLOCKING THE POTENTIAL OF FISH / ANIMAL NUTRITION: AMELIORATE GROWTH PERFORMANCE AND NUTRITIONAL SECURITY THROUGH FEED FORTIFICATION WITH ADDITIVES

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Abstract

Animal nutrition is a critical component of livestock production systems, as it directly influences animal health, welfare, and productivity. The use of feed additives in animal nutrition has gained much attention in recent years as a means of enhancing animal performance and addressing nutritional deficiencies. Fish feed fortification with additives involves the inclusion of essential nutrients, such as vitamins, minerals and amino acids, in animal feed to enhance the nutrient content and improve animal health and growth. Animal nutrition plays a crucial role in ensuring food security and human well-being. Probiotics and prebiotics are commonly used to improve gut health, while enzymes can enhance nutrient digestion and absorption. Organic acids are used to reduce microbial contamination and improve feed preservation, while antioxidants are used to protect against oxidative stress and enhance shelf-life. This article gives insight into the viability of feed fortification with additives to augment fish/animal nutrition and facilitate sustainable livestock production. The authors expound on the underlying mechanisms that confer efficacy to these additives and furnish fundamental information regarding their usage. Feed additives hold promise as a prospective remedy for enhancing animal nutrition, curtailing environmental repercussions and satisfying the mounting need for superior feed.

Keywords: *Animal nutrition, Feed additives, Enzymes, Sustainable livestock production.*

Introduction

Feed additives are small quantities of substances that are incorporated into feed ingredients or diets to enhance or maintain their quality. These additives can serve as preservatives, binders, feeding stimulants, or even feed attractants. Specific ingredients or combinations are added to the primary feed mix to meet particular requirements and are generally used in small amounts. In aquaculture, feed accounts for somewhere between 50–80% of the production costs. One of the essential components of aquaculture is proper nutrition. The right diet and affordable production costs are essential for successful aquaculture. The price and quality of the feed additives and components that are employed throughout the feed formulation process determine the nutritional value and cost of the feed, respectively. Ingredients for feed include both organic and inorganic parts. To enhance the feed quality, the fish feeding efficiency, their health and overall performance, feed additives were added during the feed preparation. Most feed additives, including antioxidants, immunostimulants, probiotics and antibiotics, are nonnutritive and are introduced to culture systems to enhance growth and water quality.

Feed manufacturers have started using functional feed additives to combat rising prices (Yousefi et al., 2019). There has been much research on the use of various additives in fish diets to reduce

psychological stress. The additive type, in addition to the species component, is crucial in differentiating the stress response. In the literature, a variety of feed additives have been tested in various species, resulting in a range of physiological reactions that have not just focused on the stress system (Herrera et al., 2019). Feed additives improve growth performance, which can help the aquaculture industry become lucrative.

Furthermore, several kinds of research have shown that the better benefits of dietary inclusion of feed additives are connected with increased feed consumption, which likely enhances immunological response and increases weight gain. Feed additives were beneficial due to their special therapeutic characteristics and eco-friendly metabolism in the digestive system. It is primarily significant for aquaculture applications because of its involvement in immune response enhancement, binding site competition, antibacterial substance generation and nutritional growth performance.

Properties of feed additives

- Feed additives should not have any harmful effects.
- It should not react with feed ingredients.
- It should not alter the nutritional quality of the feed negatively.
- It should not reduce the feed's desirable qualities by affecting its taste, appearance, flavor and texture.
- It should be available in sufficient quantities at a reasonable cost.

Types of feed additives

There are two types of feed additives

- Nutritive feed additives- Vitamins, minerals and amino acids, etc
- Nonnutritive feed additives- Binders, preservatives, etc

Feed additives

- **Probiotics**
- **Prebiotics**
- **Binders**
- **Dietary amino acid**
- **Immunostimulant**
- **Antioxidant**
- **Probiotics**
- **Antibiotics**
- **Pigments**
- **Preservatives**
- **Chemoattractants and feeding stimulants**
- **Hormones**
- **Enzymes**
- **Vitamins and minerals**

Probiotics

Probiotics are living microorganisms administered into the gastrointestinal tract (GIT) with diet or water to promote good health by improving the internal microbiological balance (Amoah et al., 2019). Fuller (1992) revised the definition as "live microbial feed supplement which beneficially affects the host animal by improving its intestinal microbial balance. In aquaculture, however, *Vibrio* spp., *Bacillus* spp., lactic acid bacteria, yeast and microalgae are mainly utilized as probiotics for growth and survival enhancement and reduction of the pathogen. It is important, especially for early life stages, since their gut is sterile and adding probiotics helps build up beneficial bacteria faster. Probiotics have been proposed as an eco-friendly way of preventing disease in aquaculture since 2008 (Wang et al., 2008).

Prebiotics

Prebiotics are non-digestible food ingredient that beneficially affects the host by selectively stimulating the growth and/or activity of one or a limited number of bacteria in the colon, thus improving host health. It is given as a feed for probiotics. A non-digestible dietary component known as a prebiotic positively influences the organism by selectively promoting the activity of one or a few specific bacteria in the gut. The use of prebiotics in rearing fish and shellfish has received less attention than other terrestrial species; despite the potential advantages to health and performance, the following factors have been looked upon in prebiotic research on fish and shellfish: growth, feed utilization, intestinal microbiota, cell loss, barrier properties to pathogenic bacteria and innate immune parameters like alternative complement activity, lysozyme activity, natural haemagglutination activity, respiratory burst, superoxide dismutase (SOD) activity and phagocytic activity (Ringø et al., 2010). The primary application of prebiotics, such as organic acids, is to sterilize feed that contains a variety of infectious and pathogenic organisms (Hinton et al., 1985).

Some of the prebiotics

Non-digestible carbohydrates, Some peptides proteins, Oligofructose, Transgalacto oligosaccharides (TOS), Lactulose, Isomalto oligosaccharides (IMO), etc.

Binders

Fish feed needs to be stable enough to endure typical handling and transportation without breaking. In addition, the fish feed has to be relatively water-stable. The starch found in the fundamental constituents of feed is gelatinized after cooking and serves as a binder in feed. Agar-agar, carboxymethylcellulose (CMC), bentonite, guar gum, lignin sulphate, plaster of paris, polyvinyl alcohol, sodium alginate and wheat gluten are among the substances used as binders used at a level of 2 to 8% to increase pellet stability (Hardy and Barrows, 2003). Heat-induced gelatinization of carbohydrates during diet preparation assists in the binding of the final feed. Any binder used in the production of fish feed pellets must be

i) It must be water stable for at least two hours.
ii) The binder must function as a source of carbohydrates in the feed and promote palatability.
iii) A binder must be inexpensive and easily available.

Binders are substances that are used in aquaculture feeds.

- ✓ To improve the efficiency of the feed manufacturing process by reducing the frictional forces of the feed mixture through the pellet dies, thereby increasing the output and horsepower efficiency of the feed mill.
- ✓ To increase pellet firmness and reduce the amount of fines produced during processing and handling.
- ✓ To improve water stability of feed.
- ✓ To minimize disintegration & loss of nutrients due to leaching.
- ✓ To improve the efficiency of the feed manufacturing process.

Classification of binders

Nutrient binders: Corn gluten, Cotton seed meal, Wheat gluten, Pre-gelatinized starch.

Non-Nutrient binders: Bentonite, Lignin sulfonate, Hemicellulose extract, Tapioca flour, Carboxymethylcellulose (CMC), Alginate, Agar.

Dietary amino acids

Providing amino acids (AA) for energy, development, protein synthesis and as substrates for essential metabolic processes, protein is the most expensive component of fish diets. AA engaged in cellular activities other than protein synthesis is referred to as functional AA. A lack or imbalance may hamper body metabolism and equilibrium in functional AA (Andersen et al., 2016). Essential amino acids (EAA) are added as a supplement to the feed to get a balanced AA profile. So supplemental EAA is added, like lysine and methionine. Using all the EAA, it is possible to lower dietary crude protein levels by 2-3%, which is a substantial saving for the farmer. The concept of an ideal protein blend from feedstuffs and feed additives will greatly help with decreasing the amount of nitrogen excreted in animal waste.

Immunostimulants

Disease-related issues have emerged to limit aquaculture's expansion in recent years. Pathogenic organisms have been spread across nations as a result of rising disease instances and, in particular, the unrestricted movement of live sea organisms. Due to these viral and bacterial epizootics, the shrimp farming sector in India and other Southeast Asian nations has experienced enormous financial losses. Immunostimulants are pharmacological substances that, whether administered alone or in combination with an antigen, activate the nonspecific immune system or the specialized immunological mechanisms, making animals more resistant to microbial and parasite infestations. A wide range of bioactive active molecules, including those with antimicrobial, antioxidant, immunostimulant, growth-promoting and anti-inflammatory properties, has been used to improve the health of aquatic animals. A novel technique has been to use bioactive molecules in aquatic feed. This bioactive immunostimulant approach is dependable, reproducible and improves feed quality (Wang et al., 2017). It is an agent which stimulates the nonspecific immune mechanisms when given alone or through specific mechanisms. Hence, there are no environmental hazards and residual effects on fish which can be given orally or through the feed. Immunostimulants promote resistance to active infection by increasing general defensive mechanisms rather than stimulating particular immune responses. As a result, there is no memory component and the response will probably only last for a short time.

- ***Natural:*** Ginger, turmeric, tulsi, garlic.
- ***Artificial:*** Beta-glucan, levan, anthraquinone, sodium alginate.

Antioxidants

The energy value of a fat or oil is significantly reduced as a result of oxidative rancidity or lipid peroxidation. Unwanted oxidation in feeds can be prevented in a number of ways. It is important to take precautions to ensure that the components used in the feeds give appropriate margins of safety for the natural antioxidants lecithin and vitamins A and E. Feed should be made with as few unstable fats and oils or other pro-oxidants as possible when feasible. Commercial fish feeds have included antioxidants in the prior. Even though hundreds of chemicals have been studied, only a select number have demonstrated the qualities required to be used in finished feeds to avoid undesired feedstuff oxidations. In the absence of natural antioxidant protection, feedstuffs rich in PUFAs are highly prone to oxidative decomposition. It may cause a reduction in the nutritional value of the constituent lipids, protein and vitamins.

- Rancidity makes feeds unpalatable and generates toxic chemicals.

Properties of antioxidants

- Inexpensive

- Non-toxic
- Effective at low concentrations (0.001–0.02%)
- Capable of surviving processing

Commonly used antioxidants are;

Synthetic antioxidant

i) Ethoxyquine @ 0.015%.

ii) Butylated Hydroxyanisole (BHA) @ 0.2%

iii) Butylated hydroxytoluene (BHT) @ 0.2%.

Natural antioxidant

i) Vitamin E

ii) Vitamin C

Antibiotics

It is a bacteriostatic or bactericidal substance added to feed to treat disease. Some feeds can be formulated with antibiotics to treat Vibriosis and other bacterial infections. In general, it has been observed that antibiotics promote the growth of young animals rather than that of adults. Feeds made with vegetable proteins respond favorably to antibiotics decreasing or stopping pathogen activity, Getting rid of microorganisms that create growth-inhibiting toxins, promoting the growth of beneficial microbes that provide nutrients, lower the number of microbes that compete with the host for nutrition. Boost the intestine's ability to absorb nutrients (Hardyand Barrows, 2003). Routine uses in the feed are not recommended. Three antibiotics approved in the U.S. are sulfadimethoxine, sulfamethazine and tetracycline (oxytetracycline, OTC).

- OTC is commercially available as "medicated" fish (shrimp) feed, 1,500 mg/kg
- Flavophospholipol- 10-40 ppm
- Virginiamycin-100ppm
- Zinc Bacitracin- 100ppm

Pigments

Fishes have a variety of colours that are defined by pigment compounds deposited in their bodies. These pigment chemicals include melanin, nitrogenous bases, luminous proteins, and xanthophylls and anthocyanins (Price et al., 2008). Carotenoids have been included in diets of salmonids, crustaceans and other farmed fish, mainly as pigments to provide a desirable coloration to these cultured organisms. Consumers subconsciously relate product color to nutritive value, healthiness, freshness and taste. Therefore, color is a decisive quality criterion that has to be maintained and optimized. The most significant types of pigments in fish and crustaceans are carotenoids. Astaxanthin and canthaxanthin give the skin and eggs colour. Because they are unable to convert xanthophylls to carotenoids, high-value culture species like salmon and red sea bream must consume these pigments. These species are given carotenoid supplements using natural materials like paprika, krill products, shrimp, and crab processing waste containing the necessary pigments. Carotenoids may not only contribute to improving quality by enhancing color but could also help to create a better image in the minds of consumers of aquaculture products. Astaxanthin is added at 50 ppm and fed to shrimp for six weeks to improve colouration.

Examples:- Capsanthin, Lycopene, Beta-8'-apo-carotenal, Lutein, Cryptoxanthin Violaxanthin, Canthaxanthin, Zeaxanthin, Patent Blue V, Curcumin.

Preservatives

Susceptibility of individual feed ingredients and formulated feeds to oxidative damage (oxidative rancidity) and microbial attack on storage. Substances are added to the feed to control the rate of deterioration, particularly from fungal attacks under favorable conditions of storage are susceptible to the growth of microorganisms like fungi, yeast and bacteria. Feedstuffs and rations with an elevated moisture content (> 15%) are prone to microbial attack and Relative humidity of 70-90% and a temperature of 25^{0}C in the tropics favour rapid growth of microbes. *Aspergillus, Fusarium and Penicillium spp*. are associated with spoilage.

Antimicrobial preservatives

Propionic acid or Ca, Na or K salt - 0.1-0.25%, Sorbic acid or Ca, Na or K salt, Benzoic acid or Na salt, Acetic acid, Formic acid, Citric acid, Ascorbic acid or Ca or Na salt, Gentian violet, Potassium and sodium bisulphite, Potassium and sodium metabisulphite, Propylene glycol.

Chemoattractants and feeding stimulants

Synthetic chemicals or natural ingredients containing chemicals like free amino acids elicit feeding responses or induce animal feeding behavior and help improve food intake. Attractants are a mix of chemicals containing nitrogenous compounds, including

- Free amino acids
- Low molecular weight peptides
- Nucleotides related compounds
- Organic bases

Two types of feeding stimulants used in aquaculture feed

Natural ingredients: Squid meal, mussel flesh, shrimp meal and waste, short-necked clam flesh, marine polychaete worms, blood worms, certain terrestrial oligochaete worms, marine fish oils, fish meal, fish soluble, fish protein hydrolysates, soybean protein hydrolysates.

Purified or synthetic chemical derivative: Mixtures of L-aminoacids; amino acid mixtures including glycine, alanine, betaine, proline and histidine.

Hormones

Growth hormone, thyroid hormone, gonadotropin, prolactin, insulin, and different steroids are among the hormones that cause fish to develop. Growth promoters include steroid hormones like androgen, estrogen, progestogens, and non-steroidal hormones like thyroxin (Naiel et al., 2020). Various natural and synthetic hormones have been used in aquaculture for

- inducement of spawning,
- sex reversal,
- production of mono-sex population,
- growth enhancement.

Hormones responsible for fish growth are 17-alpha methyl testosterone, growth hormone, thyroid hormone, gonadotropin, prolactin, insulin and various steroid. Hormonal control is used to produce monosex cultures of fish to reduce reproduction & increase growth. Ex: Androgenic steroids (ethyltestosterone) fed to tilapia fry more than 90% of males.

Enzymes

The inclusion of anti-nutritional factors like phytate (mMyo-inositol-1,2,3,4,5,6-hexakisphosphates, the primary phosphorus storage form, is one of the main issues with the use of plant proteins in fish feed. Fishes lack intestinal phytases necessary for effective phytate hydrolysis during digestion; hence, up to 80% of the total phytase content in plants may be present

in the form of phytate and is essentially unavailable to them. Therefore, the majority of the phytate-phosphorus is eventually excreted into the water, which may lead to pollution through algae growth. Enzymes aid in the improvement of the fish's inability to properly and efficiently digest its nutrition. Additionally, complex carbohydrates, collagen in skin and bones, and other feed components are all broken down by enzymes (Strobel et al., 2012). Biological catalysts, proteolytic and amylolytic enzymes are used. It improves the nutritional availability of feedstuffs. Feed enzymes have to be robust to withstand variations in pH and temperature. They should have high-temperature stability to withstand palletization. It should have a long shelf life. Phytase breaks down indigestible phytic acid (phytate) in cereals(rice bran, wheat), oil seeds and releases digestible phosphorus.

- Use of specific enzymes like **xylanase, pectinase and cellulose.** Protein levels in feed could be reduced and hence the cost factor also.

Feed Stimulants

Chemoattractants, such as free amino acids, betaine, and other naturally occurring components, including chemicals, are synthetic or natural compounds. The main flavour attractants are often thought to be extractive chemicals found in the muscles of crustaceans and mollusks. These attractants are a mixture of substances made of nitrogenous molecules, such as free amino acids, peptides with low molecular weight, nucleotides, related compounds, and organic bases. The food supplied must be appealing (i.e., scent or taste) in order to evoke an appropriate feeding response, depending on whether the animal in concern is a visual feeder or a chemo-sensory feeder. For example, whereas captive marine fish rely on sight to find food, they also rely on chemo-receptors placed in the mouth or on appendages such as lips, barbels, and fins. Dietary feeding stimulants must be used to induce an adequate and quick eating response in these farmed species. Furthermore, by employing feeding stimulants and boosting feed palatability, the time the feed spends in the water may be decreased, reducing nutrient leaching.

Aside from the feed additives listed above, there are others, like amino acids, antibiotics, and immunostimulants. L-lysine and DL-methionine are the most common synthetic amino acids used in feed supplements. These are used to compensate for deficits in a compounded diet as well as chemoattractants. Antibiotic use is prohibited since medicated feed poses health risks to consumers owing to residual buildup in the fish flesh and may also open the route for the emergence of drug-resistant bacterium strains.

Essential oils

Using herbal food additives can boost the immune system, increase feed consumption, and enhance performance by avoiding infections (Ezzat Abd El-Hack & Alagawany, 2016). Essential oil can be used as an alternative source of natural products to improve animal nutrition and prevent detrimental effects on animal health.

The most prevalent form of phytogenic compounds in aquatic feeds are feed additives, including aromatic plant essential oils. Essential oils are secondary metabolites produced by aromatic plants and are concentrated hydrophobic liquid molecules with a strong odour. Most of the plant's active chemicals are found in them, along with a range of volatile molecules such as terpenoids, aromatic components generated from phenol, and aliphatic components (Chakraborty et al., 2014) derived products that are added to the feed to boost animal performance.

Essential oil of peppermint (Talpur,2014) and cinnamon (Ahmad et al.,2011) appear to be potential options for improving growth performance, fish well-being and reducing microbial challenges in the gut. According to Zheng et al. (2009), diets enriched with oregano essential oil and its phenolic

components carvacrol and thymol were demonstrated to increase growth in channel catfish. Following eight weeks, fish fed the diet supplemented with the commercial product (0.05%) had considerably greater (P <0.05) weight increase, protein efficiency ratio, and enhanced FCR than fish fed the other diets.

Organic acids

Environment-friendly organic acids and salts commonly used as substitutes, such as acetic acid, formic acid, fumaric acid, lactic acid, propionic acid and citric acid. In combination, they act as excellent growth promoters (Balasubramanian et al., 2016). Feed conversion efficiency has been tested in salmonids, tilapia, and other fish species (Ng & Koh, 2017). Citric acid and salts are aquaculture's most studied organic acids for growth and weight gain (Zhang et al., 2016). Additionally, the benefits of citric acid with coupled amino acid-chelated trace elements have been explored as giant yellow croaker given high plant protein to digest by 0.8%-1.6% of citric acid (Chen et al., 2018).

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AGRI MIRROR : FUTURE INDIA
ISSN: 2582-6980

Article ID: 250

Diseases of Tapioca (*Manihot esculenta*) and their management

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Introduction

Manihot esculenta, commonly called cassava / tapioca is a woody shrub belongs to the family Euphorbiaceae. It is being cultivated extensively as an annual crop in tropical and subtropical regions of the world. The plant is hardy and able to tolerate drought and poor soil conditions than most other food plants. It can grow in extremely poor, acidic soils. It is propagated by planting stakes cut from the woody stems of mature plants. Mainly grown for its edible starchy tuberous root and third-largest source of food carbohydrates in the tropics, after rice and maize. It contains small amounts of calcium, phosphorus, and vitamin C. Tubers are predominantly consumed in boiled form and also used as feed, biofuel and in industries. The cone-shaped root is long and tapered, with a firm, homogeneous flesh encased in a detachable rind, the leaves are palmate (hand-shaped) and spirally arranged on stem with petioles. The plant can grows from about one to three meters in height with woody and erect stems. Cassava is vulnerable to a broad range of **diseases** caused by fungi, bacteria and viruses. Among them considerable yield loss was observed for the brown leaf spot caused by *Cercosporidium henningsii,* sett rot caused by *Diplodia natalensis,* tuber rot caused by *Phytophthora palmivora* and mosaic caused by *Indian cassava mosaic virus*. Their symptoms and management aspects were given hereunder.

Diseases infecting cassava and their management

Brown leaf spot

Symptoms

Spots are seen on both the sides of the leaves but more pronounced on upper surface. The spots are circular and brown with a distinct dark brown border. The spots increase in size and become irregular or angular and restricted by leaf margin or veinlets and measure 3 to 12 mm in dia. In the centre of brown spots, greyish growth of conidiophores and conidia are seen during humid condition. Indefinite halo around each spot or blighted area is seen. Leaves turn yellow, dry and drop off.

Fungus: *Cercosporidium henningsii* (Syn. *Cercospora henningsii, Cercospora manihotis*; Sexual stage: *Mycosphaerella manihotis*). The conidiophores are pale olivaceous brown. Conidia are cylindrical, pale olivaceous. Perithecia are black produce asci.

Mode of survival and spread: In diseased plant debris. Primary spread is from self-sown cassava and form regrowth in stored stems. Secondary spread is through wind-borne conidia.
Favourable conditions: Temperature of 27^{0}C, relative humidity of more than 90%, Aug-Sept. months and excessive N application.
Management
Remove and destroy affected leaves.
Adopt balanced fertilization.
Spray copper oxychloride 0.25% or Bordeaux mixture 1.0% at monthly interval.

Sett rot / Stem rot

Symptoms

Epidermal blisters are seen on the stem (setts). When blister ruptures black masses of pycnidia are seen on the stem. Vascular discolouration (black) and necrosis leads to stem rot. Rotting of setts leads to failure in germination. Symptoms appear in new plantings, stored cassava stakes and discarded stakes left in the field

Fungus: *Diplodia natalensis*. Pycnidia are black and large. Pycnidiospores are dark brown and two celled. Perithecia are black and globose. Each ascus contain one-celled, 8 ascospores which are colourless or olivaceous.
Mode of survival and spread: In diseased and dried stems and plant debris. Primary spread is from infected setts. Secondary spread is through wind-borne conidia.
Favourable conditions: Dry climate.
Management
Avoid wounds in stem cuttings stored for planting.
Select disease-free healthy setts for planting.
Dip setts in carboxin 0.1% or thiram 0.2% for 15 min.

Tuber rot

Symptoms

There will be no external symptom on the plant. Dark round to irregular water soaked lesions apper an mature tubers. White mycelial mats of the pathogen develop around these lesions. The lesions enlarge causing internal browning oozing of internal fluids and shrivelling of the tubers. The infected tubers emit characteristic foul smell and rot within 5-7 days.

Fungus: *Phytophthora palmivora*

Survival and mode of spread

The rotten tubers left during harvest and ploughed *insitu* serve as inoculum for the next crop and help the pathogen to survive longer periods in the soil. Flooding type of irrigation helps the pathogen for it distribution in the whole field.

Favourable conditions

High rainfall, water logging. Lack of organic mater content and narrow C:N ratio of the soil reduce population of beneficial organisum *viz Trichoderma* spp. favour the pathogen.

Management

Avoid water stagnation by giving good drainage facilities

Spot drench with copper oxychloride @ 2.5 g/l or soil application of *Trichoderma* asperellum @ 1 kg/ac as basal and at 3rd and 6th month after planting

Anthracnose

Symptoms

Deeper cankers affect the pith of the plant resulting in blockage of nutrient translocation to active growing region. On highly susceptible varieties, the depressions spread towards the top of the plant causing wilt and death of plant shoots. The most outstanding effect of the disease is its ability to cause severe stem damage causing canker on stem, necrotic spots and wilting of leaves and dieback on shoot tips. Badly infected stems become brittle and break easily under strong winds.

Fungus: *Colletotrichum gloeosporioides* Penz f.sp *manihotis* Chev

Survival and mode of spread

In diseased and dried stems and plant debris. Primary spread is from infected setts. Secondary spread is through wind-borne conidia.

Favourable conditions: cool and moist conditions, stakes stored in shades during rainy days. **Most favourable temperature for development of the disease is about 21 °C.**

Management

Avoid wounds in stem cuttings stored for planting.

Select disease-free healthy setts for planting.

Dip setts in carboxin 0.1% or thiram 0.2% for 15 min.

Cassava mosaic

Symptoms

Mosaic symptoms are first seen on younger leaves. Infected leaves exhibit dark green areas separated by normal green tissues, distortion of lobes, reduced size, misshapen and twisted. Infected plants are stunted. The stems are thin and soft. Tubers are small, show longitudinal splitting, contain high fibre and unfit for consumption. The disease reduces the quality and quantity of tubers and seed-stems. The plants infected soon after germination of setts do not grow further and dies soon.

Virus: *Indian cassava mosaic virus* (ICMV) belongs to Begomovirus with ssDNA.

Mode of survival and spread: In setts, volunteer plants. Primary spread is from infected setts, diseased plants. Secondary spread is through insect vector, whitefly (*Bemisia tabaci*).

Management

Plant resistant varieties (MnGa-1) or hybrids.

Plant virus-free planting materials obtained from meristem tip culture or setts from healthy plants.

Rogue out and destroy infected plants. Place yellow sticky traps at 12 Nos. ha to attract and monitor insect vector population.

Spray neem oil @ 3 % (with teepol at 1 ml/l) or fish oil rosin soap @ 25 g/l or methyl demeton 25 EC @ 2 ml/l to control vector.

Avoid extending the crop growth beyond its duration.

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