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INDEX

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ABRUS PRECATORIUS (ROSARY PEA) – MEDICINAL USES AND TOXICOLOGICAL OVERVIEW

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Abstract

Abrus precatorius, also known as Rosary pea is one of the valuable plant species native to Asia and Australia. Despite the number of health benefits, it is also being used as an ornamental plant. It is found to be effective in the treatment of migraine, inflammation, ulcers, wounds, throat scratches and sores, gonorrhea, jaundice, promotes hair growth and acts as abortifacient. Seeds and leaves of this plant are found to produce abrin, a deadly poison which is proven to be fatal for both humans as well as animals when consumed in greater amounts. Researchers have concluded that high temperature processing can lead to the destruction of toxicity to some extent though proper research needs to be conducted.

Key words : Abrin, health benefits, toxicity.

Introduction

Nature has always blessed humans by providing numerous valuable plant species. *Abrus precatorius* is also one of them. *Abrus precatorius* is also known as Rosary pea which belongs to the family *fabaceae* and is native to Asia and Australia. The plant has been used or various medical purposes since ancient times and also being used as ornamental plant. The plant grows up to a height of 10-20 ft and flowers bloom as bluish pink in color which forms clusters. *Abrus precatorius* resembles the tamarind leaves with 20- 40 leaflets. The plant grows well in slightly acidic soil to slightly basic which ranges from pH 5-8. The fruits of this plant are flat and like a pod which is 3-4cm long and 1.2 cm wide (Anand *et al*., 2010). It is widely propagated through seeds and used for many medicinal purposes. In India *Abrus precatorius* is seen in all over Himalayas and to the southern part too. The plant is found to be effective against the treatment of migraine, inflammation, ulcers, wounds, diabetes, tumor, throat scratches and sores, gonorrhea, jaundice, also promotes hair growth and acts as abortifacient (Bhakta and Das, 2020). But despite of the number of health benefits, people are unaware of the toxicological effects, seeds and leaves of this plant possess which are proven to be fatal for both animals and humans when consumed in more than measurable quantity.

Toxicology of *Abrus precatorius*

All the parts of the plant are toxic when consumed in overdose. The main toxin is produced by seeds also known as Abrin which is a protein based toxalbumin similar to snake venom. It inhibits the protein synthesis which results in cell death (Narayanan *et al*., 2005). When the person consumes the seeds of this plant as raw, it leads to vomiting, bloody diarrhea, abdominal pain, gastrointestinal bleeding, irregular pulse, weakness and dyspnea

(Karthikeyan *et al*., 2017) which can occur from 24 hours to 5 days of consumption. A number of cases are reported of *Abrus poisioning*, one such involves a 16 year old girl who unintentionally ate the crushed seeds of *Abrus precatorius*. On admitting to the hospital, she was identified with severe abdominal pain, red urine and black stools after 6 hours of the consumption (Huang *et al*., 2017). Researchers have concluded the high temperature treatment can cause an effect on lowering the toxicity to some extent which will be fit for consumption.

Table 1 : Chemical constituents of *Abrus Precatorius* (Bhakta and Das, 2020)

SN	Plant Parts	Chemical constituents	Medicinal purpose
1	 Leaves	Glycyrrhizin, triterpene glycosides, pinitol and alkaloids such as abrine, hypaphorine, choline and precatorine, Abruslactone, Abrusoside, Inositol	Anti-bacterial, Analgesic, anti-fungal, anti-tumor, anti-spasmodic, anti-diabetic, anti-migraine, abortifacient, acts against inflammation, ulcers, wounds, throat scratches and sores (Anant and Maitreyi, 2012).
2	 Flowers and roots	Glycyrrhizin and alkaloids like abrasine and precasine besides abrine, Abrol, Precol.	
3	 Seeds	Abrine, hypaphorine, choline and precatorine(alkaloids present in seeds), abricin, cholesterol, Abrus agglutinin, Saponin, Flavonoids, Abrectorin, Precatorin, Lectin, campestanol	

Conclusion

As far as the health benefits are concerned, *Abrus precatorius* is effective against the treatment of migraine, inflammation, ulcers, wounds, diabetes, tumor, throat scratches and sores, gonorrhea, jaundice, hair growth and acts as abortifacient. The toxicity as a whole is concerned with seeds of the plant and researchers have concluded the heat processing technique as one of the best way to lower down the toxic effects for a safe consumption.

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AGRICAFE : A SUCCESSFUL CASE STUDY OF ENTREPRENEUR

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Entrepreneurship as a concept gathered prominence in economic literature mainly through the writings of **Richard Cantillon (1680-1734),** who gave the concept some analytical treatment and assigned the entrepreneur an economic role by emphasizing on 'risk' as a prominent entrepreneurial function**.** According to encyclopedia Britannica entrepreneur means individual response for the operation of the business, including the choice of a product, the mobilization of the necessary capital, decisions on product prices and quantities, the employment of the labour and expanding or reducing the productive facilities.

According to **Weber (1930)** entrepreneurs are the product of particular social conditions in which they live and it is the society which shapes the personality of individuals as entrepreneurs.

According to **Schumpeter (1961)** an entrepreneur was a dynamic agent of change, or the catalyst who transformed increasingly physical, natural and human resources into corresponding production possibilities. According to **Hagen (1962)** entrepreneur as a creative problem solver interested in things in the practical and technological realm most entrepreneurial activities do not involve innovative techniques to any considerable degree but rather involve coping with the method of doing business and of combining inputs quite similar to those combinations already in existence.

According to **Joshi and Kapoor (1973)** farm entrepreneur is the person or a group of persons who organizes and operate the business and is responsible for the results i.e. Losses and gains from the business. He is pioneer in organizing and developing the farmers.

Successful case study

Agricafe Business Pvt.Ltd is a startup company founded by Lilanshu Arora and Deepti arora in 2016. This startup is initiated to work for overall development of farmers, through innovative ideas and plans. Agricafe works hard to become leading company in developing viable and sustainable agriculture enterprises. They are inspired by Digital India programme. The main aim of this company is to connect the farmers to cashless economy through digitalization. This company is also educating farmers on best farming practices and encouraging farmers to invest intelligently in ventures like apiculture, sericulture, aquaculture, mushroom farming etc. so as to achieve income security. This company aims at bringing wide range of agriculture products, services and solutions through Kissan Bazaar and Service Pool. The main moto of this company is to provide transparency and quality services to farmers. This company provides advisory to farmers on crop selection, best farm practice, post-harvest value - addition options, key agricultural information like internet-based weather forecast, price trends, market news, risk mitigation and crop insurance, credit and input access, for the benefit of the farmers. Farmers can register and login to their application software and can send their queries, where the best solution will be provided by the experts. Beside this, they provide farmers the option of online shopping. Farmers can get all the Agricultural equipment

including insecticides and pesticides on their doorstep at reasonable prices through our Kissan Bazar segment. An entrepreneur should have many characteristics like Innovation Seeking**:** Agri cafe has linked farmers to the marketing segment for selling their produce at good prices through an online portal. They also provide consultancy to farmers regarding Crop choice, cropping pattern and risk mitigation advise. The other one is Employment provider that an entrepreneur is employment provider rather than employment seeker. Through this enterprise many people are employed in AgriCafe centres. Risk Bearing ability is also one ability of an entrepreneur. An entrepreneur should be risk bearer. An entrepreneur should have internal motivation which motivate him or her to start new initiatives. In 5 years the enterprise has shown rapid progress and spread across Gram Sabha of 13 districts of Uttarakhand. This progress has motivated new entrepreneurs in this field. AgriCafe shows positive impact on the lives of farmers. Farmers have benefited from AgriCafe advisory and reported incremental crop yield and lower post harvest losses. The online portal of AgriCafe provided cheap agricultural equipment to the farmers.

Conclusion

Entrepreneurs should have some characteristics so that they can establish their own enterprise. An entrepreneur should be risk bearer, motivator and have positive attitude towards any situation.

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ANIMAL GENETIC RESOURCES OF MIZORAM

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Livestock production in Mizoram is primarily in the hands of the small holders. Livestock farming is an important element in mixed farming system prevailed in the state because of high preference of meat in people's diets. Nearly 90 per cent of the rural households keep at least one species livestock. The state has a total number of 359704 livestock and 2047810 poultry. The rural areas and urban areas of Mizoram has 224264 and 135440 livestock respectively while the poultry population of rural and urban areas is 1310814 and 736996(20th livestock census, Govt. of India).There are less number of registered breeds in Mizoram. Animals are mainly reared on extensive management system.

Bovine

The total bovine population in the state is 51767 out of which cattle population is 45701 and buffalo 2109 while Mithun population is 3957(20th livestock census, Govt. of India). Majority of the livestock 32709 cattle heads (71.57%), 3912 Mithun heads (98. 86%) and 1813 buffalo heads (85.96%) are reared by rural people.

Cattle and Buffalo

There is no registered indigenous cattle breed in the state and all indigenous cattle are known as Desi. The Desi cattle are small in size and have cylindrical type body. The body colour varies brown (85%), black (11%) and grey (4%). The cattle have well-built and compact body with strong legs.

Production and reproduction parameters

The birth weight of Mizo cattle varies from 10-15kg. The averageadult body weight of cow andbullock weigh about 169 kg and 200 kg respectively. The daily milk yield ranges from 1.5 to 3.5 kg and lactation length varies from 150-210 days (average 178 days). The age at first calving, dry period, service period, calving interval are 1160 days (28 to 42 months), 132days (120-150 days), 121 days (90-120 days) and 638 days (12-24 months), respectively. The herd life is 15-20 years and number of calving during life time 8 -10 calvings. Milking is usually done once in a day and also milking time is irregular which may be the reason for low productivity. Furthermore, low milk productivity in the cowsmay be because very less number of farmers are keeping cattle for milk production and they mostly prefer Mithun and cattle crosses because of better productivity in terms of milk, draft and beef.

Rearing of buffalo is not popular in the state. Majority of buffaloes are swamp buffaloes and few Murrah buffaloes reared by the farmers (Govt.of Mizoram, 2007).

Mithun

Mithun husbandry plays a significant role in the socio-economic life of Mizo-society since time immemorial. Keeping Mithun is considered as sign of prosperity in the tribal community of the state and also used for marriage gift and sacrificial purposes in cultural practices. The strain of Mithun reared in the state is as Mizoram Mithun. According to 20th livestock census the population of Mithun in Mizoram is only 3957 which is the lowest among North-East

States. Conservation of this holy animal and uplifting the population is the major challenge before the state government.

Mithun has a very compact muscular body with a 'V' shaped head with broad and distinct frontal bone. The coat colour around head is usually black with greyish fore head or white fore head and white face. The predominant body colour in Mizoram Mithun is jet black, however, white patches coat colour also seen to some extent.

Adult Mithun weighs approximately 400–500 kg (Tamhan et al. 1977) and can reach up to 567 kg (Bhusan 1993).If the animals are fed well can grow up to 300 to 600 g per day. Mithun is considered as holy animal by the tribal community and sacrificed for meat only on the occasions of important social rituals and festivals. Mithun meat has high demand among the consumers and considered as more tender and superior over the meat from any other species apart from pork (Mandal et al., 2014). Mithun is a poly-estrous animal. The estrus cycle is 19-24 days interval and mostly shows silent estrous without bellowing and expressing standing heat period of 4-16 hours. The gestation period ranges from 290-320 days. The age at puberty varies from 18-24 months and age at first calving range is 35-40 months. The service period and inter-calving period is 50-100days and 400 days, respectively.

Pig

Pig is the most commonly reared livestock by the Mizo community. The total population of pigs in Mizoram is 0.29 million (20th livestock census) with an increase of 19.26% from previous census (19th livestock census). Zovawk is a national registered pig breed found in Mizoram. It is reared by Mizo community for pork and manure. Animals are black with white spot on forehead, white patches on belly and white boots. The pigs have erect ears, concave snout, pot belly, concave top line and long bristles on mid-line.

Production and reproduction parameters

Average body weight is 54kg in males and 59 kg in females. The average body weight is 54-60 kg. The average age at first fertile service, average age at first farrowing, gestation period, average litter size at birth was 323.75 ± 9.90 days, 437.75 ± 9.41 days, 113.63 ± 0.53 days, 7.13± 1.18 respectively (Hmar et al., 2010; Kalita et al., 2018). Besides Zovawk pig, few exotic breeds are also available like Hampshire, Large White Yorkshire and Landrace which are used for up gradation of indigenous nondescript pigs.

Poultry

Local indigenous chickens are reared for dual purpose mainly under free range scavenging conditions using kitchen leftover, crop residues, worms, insect, grass and grains as feed materials. Chicks get hatched by natural hatching at home using bamboo made brooders.

Productive performance of local chicken

Several research workers have reported the production performance of the locally reared chicken. The average age of hen at first laying was 7.5 months and average age at sexual maturity was 7-8 months. The average hatchability was 60-70 % and egg weight ranges from 35 to 40 gm. The average number of egg production was 72/hen/annum. The average body weight at 12 months was 1.5-2 kg (Deka et al. 2003).

One more local bird called Sikhar is one of the deshi/local type of chicken reared in extensive backyard system of rearing in different parts the state. Being an indigenous bird, it can survive and produce with irregular supply of feed and water with inadequate healthcare facilities. Shikhar bird is being reared for catching Red Jungle Fowl from the forests during the months

from March to June as part of game or for consumptions as the meat is highly demanded than the commercial broilers. Adult Sikhar birds are sold at very expensive prices as high as Rs. 3000/- for every pair of a cock and a hen in spite of the low production performance of the birds.

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IMPROVING MAIZE PRODUCTIVITY AND QUALITY THROUGH AGRONOMIC BIOFORTIFICATION

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Abstract

The demand for food is increasing to feed the population and to ensure food security. In developing countries, micronutrient malnutrition is dominant mainly in resource poor families. Low content of Fe and Zn in the diet can be the major reason behind deficiencies of Fe and Zn in human beings. Biofortified maize is a possible viable option for sustainable and cost-effective solution to overcome malnutrition. Agronomic biofortification is a process in which plants are allowed to take up the mineral from the soil and accumulate them in the grains so as to produce nutritionally rich grains that support dietary requirement of human. Development of multinutrient rich maize would help in providing nutritional security more holistically. Thus, agronomic biofortification where possible, is the most cost effective and sustainable solution for tackling the micronutrient deficiencies as the intake of micronutrients is on a continuing basis with no additional costs to the consumer in the developing countries.

Keywords : Agronomic biofortification, Malnutrition, Nutritional security

Introduction

Maize (*Zea mays*) is also known as corn, *makka* or *makki* which belongs to family *Poaceae*. It is world's 3rd most important cereal crop after rice and wheat. It is produced largely worldwide than any other cereal grain and it has a pivotal role in increasing the income of both subsistence and commercial farmers. Maize is known as "Queen of Cereals" and is grown in more than 130 countries worldwide. Intensive agriculture involving use of modern technologies for production along with the introduction of high yielding sweet corn, coupled with use of high analysis fertilizers has resulted in the deficiency of micronutrients, mainly zinc and iron. Maize is a main source of calories and minerals for most of the people living in rural areas. But unfortunately, maize is inherently poor in content of protein and minerals particularly zinc. It is a high nutrient demanding crop which is sensitive to micronutrient deficiency especially Zn. Thus, agronomic biofortification in the form of various fertilizer application, has become an important agricultural practice to increase the delivery of prime nutrients to crop tissues.

Different Use of Maize

Maize is used as a staple food for humans, feed for livestock and raw material for industrial purpose. It is one of the most important food resources of human and as C_4 crop absorbs high amounts of nutrients from the soil. Maize is enriched with protein known as *zein*. It has high nutritional value as it contains about 62.3% starch, 11.1% protein, 4.6% oil, 1.8% fiber, 4.3% sugar and 1.3% ash. Different alcoholic beverages and industrial products are produced by maize distillery and fermentation industries. The fermentation of maize starches has made it important feed stock for ethanol which is being used as a bio-fuel; a mixture of 10% ethanol and 90% gasoline is called as 'gasohol'. In India, at present, about 35% of the maize produced

in the country is used for human consumption, 25% each in poultry feed and cattle feed and 15% in food processing (corn flakes, popcorn etc.) and other industries such as starch, dextrose, corn syrup, corn oil *etc*.

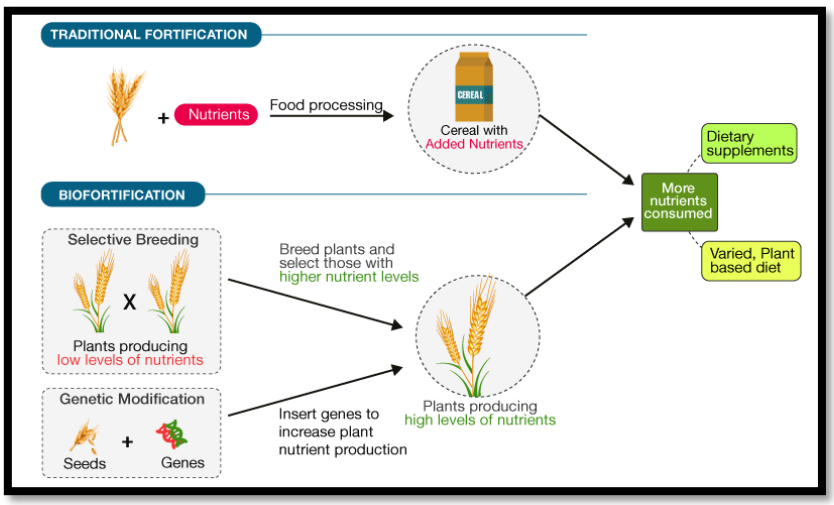
Current Status of Maize Cultivation

India ranks fifth in area and third in production and productivity among cereal crops. In India, maize is being cultivated in an area of 8.38 million ha with a production of 19.78 million tons and an average productivity of 2.36 t ha^{-1} the fifth largest producer in the world contributing 3 percent of the global production. Among the major producing states in India, Andhra Pradesh tops the list with the contribution of 17% to the total Indian maize production. It indicates that productivity of maize in India is still lower than the productivity of world. Maharashtra in particular is much lower than world average with productivity of 4.34 t ha^{-1}.

Necessity of Biofortification in Maize

Among micronutrients, Zn and Fe deficiency is occurring in both crops and humans. About half of the world's population suffers from micronutrient malnutrition, including iron, zinc and iodine which are mainly related with low dietary intake of micronutrients in diets with less diversity of food. Recent research shows that approximately 5,00,000 children under 5 years of age die annually due to Zn and Fe deficiencies. Zinc deficiency is currently listed as a major risk factor for human health and cause of death globally. Though iron (Fe) is the second most abundant metal in nature and fourth most abundant element in the earth crust, about 11% Indian soils are in deficient supply of iron (Singh,1999). As per WHO report on the risk factors responsible for development of illnesses and diseases, Zn deficiency ranks 11th among the 20 most important factors in the world and 5th among the 10 most important factors in developing countries. Incidence of zinc deficiency in soils is becoming more important due to its impact on human health (Singh *et al.*, 2005). Increasing productivity through proper management is one of the important strategies to increase the production of maize as well as micronutrient enrichment in grains.The reliance on cereal-based diets may induce Zn and Fe deficiency-related health problems in humans, such as impairments in physical development, immune system and brain function. Biorfortification can be a solution of all these problem. It is of mainly two types i.e. genetic biofortification, traditional or agronomic biofortification (Fig. 1). Among these two strategies, plant breeding strategy (genetic biofortification) appears to be a most sustainable but it is too much time consuming and not cost-effective approach for improving Zn and Fe concentrations in grain. So, agronomic biofortification can be an alternate viable option.

Fig. 1: Methods of Biofortification



Agronomic Biofrtification in Maize

Biofortification is a process in which plants are allowed to take up the minerals (Zn) from the soils and immobilize them in the grains so as to produce nutritionally rich grains that support dietary requirement of humans. Maize is a high nutrient demanding crop, which also requires micronutrients (in particular the Zn) (Obrador *et al.*, 2003) along with major elements for better growth and yield (Verma, 2011). Zn, B, Fe, Mn are the important micronutrients for maize crop. Thus, agronomic biofortification with soil and foliar applications of micronutrient not only increase the corn yield but also improve the nutrient quality of the specialty corn for obtaining good economic returns and also nutritional security.

Effect of Agronomic Biofrtification in Maize

With application of recommended dose of fertilizers (120- 50- 40 N, P_2O_5, K_2O kg ha^{-1}) + soil application of 50 kg $ZnSO_4$ ha^{-1} along with foliar application of 0.2% $ZnSO_4$ at 30 and 40 DAS recorded the maximum dry matter production (6695 kg ha^{-1}) of maize (Sulthana *et al.*, 2015). Duraisami *et al*. (2007) reported that with soil application of 5 kg Zn + 40 kg S + 1.5 kg B ha^{-1} maximum zinc content was noticed in grain (79.1 mg kg^{-1}) and stover (92.7 mg kg^{-1}), which was however comparable with application of 5 kg Zn + 40 kg S + 1.5 kg B + 0.5 kg Mo ha^{-1}. Kumar and Salakinkop (2017) revealed that, significantly higher Zn (47 mg kg^{-1}) and Fe (75.2 mg kg^{-1}) density in maize grain was recorded with soil application of FYM enriched with $ZnSO_4$ and $FeSO_4$ each @ 25 kg ha^{-1} than control and it was on par with the soil application of FYM enriched with $ZnSO_4$ and $FeSO_4$ each @ 15 kg ha^{-1}. Tariq *et al.* (2014) reported that the soil and foliar application of $ZnSO_4$ obtained significantly maximum grain and stover yield over control. Similarly, Khan *et al.* (2015) reported that the soil application of 15 kg ha^{-1} $ZnSO_4$ and 15 kg ha^{-1} $MnSO_4$ significantly increased the biological yield (20.15 tons ha^{-1}) and grain yield (7.42 t ha^{-1}) of maize. Hossain *et al.* (2011) stated that differential response was observed in yield among the maize varieties to Zn fertilization. Like seed yield, the stover yield of maize for all varieties increased significantly due to Zn fertilization. Agronomic biofortification of RDF+ $ZnSO_4$ @ 20 kg ha^{-1} + $FeSO_4$ @ 30 kg ha^{-1} was recorded significantly superior grain yield (85.64 q ha^{-1}), stover yield (110.16 q ha^{-1}) beings at par with RDF + $ZnSO_4$ @ 20 kg ha^{-1} and RDF + $FeSO_4$ @ 30 kg ha^{-1} (Table 1). The increase in seed yield is ascribed to the reason that application of zinc, iron and sulphur along with nitrogen, phosphorus and potassium resulted in vigorous root development, which promotes growth and development of plant leading to higher photosynthetic activity, which in turn results in better development of yield attributes.

Table 1: Grain yield (q ha^{-1}), stover yield (q ha^{-1}), biological yield (q ha^{-1}) and harvest index (%) of maize as influenced by various treatments (Sonone, 2019)

Treatments	Grain yield (q ha-1)	Stover yield (q ha-1)	Biological yield (q ha-1)	Harvest index (%)
RDF (120:60:30) NPK kg ha^{-1}	78.28	101.73	180.01	43.45
RDF + $ZnSO_4$ @ 20 kg ha^{-1}	83.23	107.01	190.24	43.75
RDF + $FeSO_4$ @ 30 kg ha^{-1}	82.14	105.61	187.75	43.75
RDF + $ZnSO_4$ @ 20 kg ha^{-1}+ $FeSO_4$ @ 30 kg ha^{-1}	85.64	110.16	187.75	43.74
SE(m)±	1.56	2.00	3.53	-
CD at 5%	4.57	5.87	10.34	-

Faujdar *et al.* (2014) revealed that application of FYM @ 10 t + 7.5 kg Zn ha^{-1} followed by inoculation with Azotobacter + VAM resulted in significantly higher iron content in grain and stover in maize during two consecutive years of study compared to the rest of the treatments

tried at Faisalabad, Pakistan. Subramanian *et al.* (2009) opined that mycorrhizal symbiosis enhances Zn supply to the host plants by extensive root development enabling the plant to maintain higher nutritional status and produce grains with rich tryptophan concentrations. Subramanian *et al.* (2014) revealed that the inoculation of Zn + P + AMF (*Glomus intraradices)* had significantly higher root length (AMF- 16.8; AMF+ 23.5 cm), root volume and leaf area in maize. Matsumura *et al.* (2013) found that the inoculation with AMF significantly increased maize dry matter production over control. Abdelmoneim *et al.* (2014) revealed that the inoculation of AM fungi (*Glomus mosseae)* increased the plant height, stem length, root length, plant fresh weight, shoot dry weight, root dry weight and root/shoot ratio in maize.

Khan *et al.* (2014) reported that soil application of 15 kg $ZnSO_4$ + 15 kg $MnSO_4$ ha^{-1} resulted in higher protein content (8.96%) in maize compared to rest of the treatments in Faisalabad, Pakistan. Aruna *et al.* (2006) revealed that improved the protein content in maize with foliar spray of 0.5 % of zinc sulphate at 50 % silking stage; as compared to soil application of 50 kg $ZnSO_4$ ha^{-1}. The increase in the protein content might be due to marked influence of Zn treatments on the enzymatic activity in the plants which could bring about significant changes in the crude and true protein contents in maize grains. Zinc is essential for protein synthesis, reduction in RNA-polymerase activity and increase in RNA destruction. Formation of NADPH or NADH depending on the Zn concentration might have involved in tapping and converting the radiation energy for photosynthetic activities and increased formation of sugars and starch. Among the three specialty corn, sweet corn significantly improved the starch content in corn grain. Higher starch content of 71.54% was obtained with sweet corn and the starch content 63.44% and 62.20% with QPM and popcorn respectively. Likewise, grain starch content of specialty corn as influenced by applying Zn_4 resulted in higher starch content (67.76%) compared to Zn_2, Zn_3, Zn_1, Zn_5 and Zn_0 (66.55%, 65.63%, 65.32%, 64.98% and 64.12%) respectively (Table 2). Interaction effect between three types of corn and Zn on starch content of specialty corn was found to be non-significant.

Table 2 : Protein content (%) and starch content (%) as influenced by different types of corn and zinc levels (Debnath *et al*., 2016)

Treatments	Protein content (%)	Starch content (%)
Specialty corn types		
Pop corn	6.80	62.20
Sweet corn	5.61	71.54*
QPM	7.89	63.44
SEm±	0.18	1.97
CD (P=0.05)	0.53	5.66
Zinc levels		
Zn_0 (Control, only recommended dose of fertilizer)	5.70	64.12
Zn_1 (12.5 kg ZnSO4 ha^{-1} as Soil application)	6.35	65.32
Zn_2 (25 kg ZnSO4 ha^{-1} as Soil application)	7.77	66.55
Zn_3 (Zn_1 + 2 Foliar sprays at tasseling and milking stage)	6.51	65.63
Zn_4 (Zn_2 + 2 Foliar sprays at tasseling and milking stage)	8.09	67.76
Zn_5 (2 Foliar sprays at tasseling and milking stage)	6.18	64.98
SEm±	0.26	2.78
CD (P=0.05)	0.76	NS
Interaction (C × Zn)	NS	NS

***** Starch content was analysed in green cob stage only

Chand *et al.* (2017) reported that the cob length was significantly increased by the different zinc fertilization treatments with soil application of $ZnSO_4$ @ 25 kg ha^{-1}+ foliar spray of $ZnSO_4$ @ 0.2% at 25 and 40 DAS which recorded significantly higher cob length (19.03) over control. Maximum cob length (9.13 cm) was found with application of 5 t ha^{-1} of FYM + 100 kg of inorganic N ha^{-1} followed by application of 100 % recommended nitrogen (8.94 cm) (Singh *et al.*, 2016). Mohsin *et al.* (2014) found that the combined application of Zn as seed priming (2.0%) and foliar spray (2.0%), significantly improved plant height, cob length, cob diameter, 1000-grain weight and biological yield in maize. Mohseni and Haddadi (2015) found that the application of Zn + B had significant effect on length and diameter of corn ear. Khan *et al.* (2015) reported that the soil application of ZnSO4 and MnSO4 significantly increased the plant height at maturity (225 cm), cob diameter (4.29 cm) and number of grains per cob (415) in maize.

Girth of cob, cob length was significantly influenced by different micronutrient management (Fig. 2). Foliar application of 0.5% of $ZnSO_4$ + 0.2% $FeSO_4$ at booting and silking along with RDF (N, P_2O_5 and K_2O 180:60:50 kg ha^{-1}) (T_{10}), recorded significantly higher cob length (22 cm) over the rest of the treatments which was however comparable with soil application of $ZnSO_4$ @ 50 kg^{-1} + $FeSO_4$ @ 25 kg ha^{-1} + RDF, 0.5% foliar application of $ZnSO_4$ + 0.2% $FeSO_4$ at booting + RDF and 0.2% foliar application of $FeSO_4$ at booting and silking + RDF (T_4, T_9 and T_8). RDF (N, P_2O_5 and K_2O 180:60:50 kg ha^{-1}) (T_1) recorded the lowest stature of cob length (11 cm) compared to soil applications of $ZnSO_4$ @ 50 kg ha^{-1} + RDF, soil application of $FeSO_4$ @ 25 kg ha^{-1} + RDF and 0.5% foliar application of $ZnSO_4$ at booting and silking + RDF, (T_2, T_3 and T_6). T_{10} recorded significantly higher cob girth (17 cm) over the rest of the treatments tried, which was however comparable with 0.5% foliar application of $ZnSO_4$ + 0.2% $FeSO_4$ at booting + RDF, soil application of $ZnSO_4$ @ 50 kg ha^{-1} + $FeSO_4$ @ 25 kg ha^{-1} + RDF and 0.2% foliar application of $FeSO_4$ at booting and silking + RDF (T_9, T_4 and T_8).

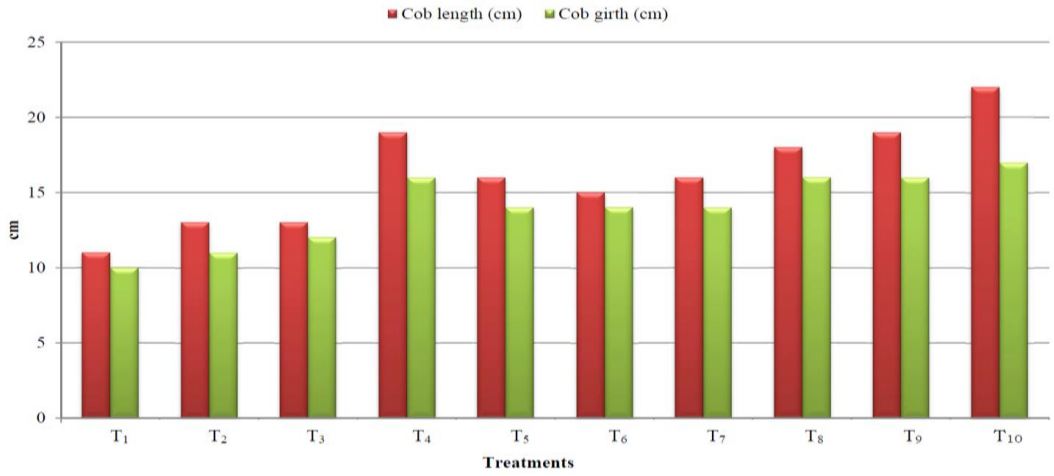


Fig. 2: Cob length and Cob girth (cm) of sweet corn as influenced by zinc and iron nutrition (Karrimi *et al.*, 2018)

Conclusion

Biofortification with micronutrients is becoming regular practice and zinc and iron are the front liner in maize biofortification. Hence, there is a possibility of enriching nutrient content of grain by biofortification. It is considered to be potentially more cost-effective than other methods to deliver the benefits of micronutrient enhancement to the rural populations in developing countries.

Maize crop responded widely to Zn fertilization and the crop is very sensitive for Zn deficient soil. Zinc sulphate application either through soil (or) foliage enhances the growth and yield attributes resulting in higher yield and grain quality. Thus, for maximizing maize yield, it is essential to see the way to increased productivity but more research and farmer's awareness is needed. However, agronomically biofortified maize will enhance the nutritional security and also maintain the environmental sustainability.

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QUALITY AND COMPOSITION OF BOVINE COLOSTRUM

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Abstract

Colostrum is the first natural nutrient for new born calves. It is a rich source of energy, protein, fat and the only source of natural passive immunity available. Good quality colostrum has more than 50 mg/mL IgG, which is the major source of immunoglobulins providing passive immunity at early life of the calves. Besides immunoglobulins, nutritional and microbial quality is also important. Bacteria in colostrum attach to free immunoglobulins in the intestinal lumen and block absorption of these molecules by retarding pinocytosis through enterocytes of lumen, therefore the threshold level for total plate count (<1,00,000 cfu/ml) and Enterobacteriaceae (<10,000 cfu/ml) should be considered. Colostrum feeding should be done immediately after birth otherwise the IgG absorption diminishes and ceases approximately by 24 hours of life. Non-availability or inadequate absorption of sufficient IgG through colostrum would lead to failure of transfer of passive immunity (FTP) in calves and one of the major contributing factor for calf mortality.

Key word : Colostrum quality, Calf, Immunoglobulins, FPT

Introduction

Colostrum is the first lacteal secretion produced from the mammary gland immediately after parturition mostly secreted for 72 hours post-partum. Colostrogenesis starts during the last three weeks of gestation by transportation of immunoglobulin (passive transfer of IgG_1 and selective transfer of IgG_2) from serum to mammary gland under the influence of lactogenic hormones and other regulatory factors. This process continues throughout late gestation but abruptly stops at the time of calving. During colostrogenesis, up to 500 g/week of immunoglobulin G (IgG) can be transferred into mammary secretions, with highest concentration just before calving under the influence of prolactin hormone. Colostrum is considered as “liquid gold” for new born calf as it is rich in nutritional, antimicrobial, growth factors and is the only source of natural passive immunoglobulins (Ig) that are essential for stimulating immune defense system of the newborn calf. Immunoglobulin can’t cross placental structure in cattle because the separation of fetal and maternal blood supplies prevent *in utero* transfer of immune factors, so agammaglobulinemic calves are born with less circulating IgG or IgM. The proteolytic system in cattle remains immature from birth until three weeks of age and they are unable to digest proteins other than from milk. The pH of colostrum is low initially (with an average value of 6.32) and increases with time post-partum (reached 6.5 after 2 weeks). This low pH of colostrum is due to the increased concentration of citrate, protein, carbon dioxide and dihydrogen phosphate. The buffering capacity of colostrum is defined as the resistance to changes in pH with addition of acid or base and the principal buffering components present in colostrum are proteins, citrate, carbonate, soluble phosphate and colloidal calcium phosphate which results in higher buffering capacity of colostrum as compared to milk. Similarly, the titratable acidity of colostrum is approximately 2 to 2.5 times higher than that of milk (Tsioulpas *et al.,* 2007). Colostrum is yellow in color due

to the presence of carotenoids and β-carotene is responsible for 65% of variation in color index of colostrum (Calderon *et al.,* 2007). Due to the presence of high protein (casein) and calcium ion (Ca^{+2}) concentration, higher size of casein micelles are found in colostrum. Somatic cell count of colostrum is higher than milk but this is not due to mastitis. It is due to the penetration of cells through leaky tight junctions between the mammary epithelial cells. The main health benefits of colostrum are immune-modulation, improvement of gastro-intestinal function by inhibiting the colonization of harmful pathogens in gut and by promoting growth of beneficial bacterial colonies, growth stimulation by increasing bone density and delays aging process. Colostrum also possesses laxative effect that helps in passing of first stool, called meconium.

Composition

The composition (nutritional and biological value) and chemical properties of colostrum is highly variable.

Table-1.Chemical composition of colostrum and milk with each hour post-partum (Grodzki, 2011).

Colostrum(hours)	Protein (%)	Fat (%)	Lactose (%)	Casein (%)	Albumin,Globulin(%)
0	16.8	6.7	2.9	4.1	12.7
6	11.7	6.1	3.5	3.5	8.0
12	6.3	4.4	3.9	3.1	3.2
24	5.5	4.1	4.1	2.9	2.6
48	4.8	3.9	4.2	2.8	2.0
120	3.6	0.8	4.5	2.7	0.9
Milk	3.2	3.8	4.6	2.6	0.6

Casein is known as milk protein and its concentration is higher in colostrum along with alpha-lactalbumin, beta-lactoglobulin and bovine serum albumin that decreases gradually with subsequent milking. Colostrum is the rich source of immunoglobulins (Ig). These immunoglobulins are monomeric or polymeric proteins which are divided into different classes – A, D, E, G, H, M based on different biological, immunological and physicochemical properties in animals. Bovine colostrum contains IgG, IgA and IgM. Immunoglobulin G (IgG) is the major immunoglobulin (65-90%) present in colostrum which is produced from plasma cells of the lymphatic system and is known as primary Ig. There are two isotypes of IgG- IgG1 and IgG2 having ratio of 35:1. The calf produces its own immunoglobulin around 36 hours of age and through the first 3 weeks of age an approximate of 1g IgG is produced. IgM and IgA contribute 8-10% and 7-10% respectively of colostrum's immunoglobulin protein. Colostrometer helps in quantitative estimation of IgG in farms. Lactoferrin, an iron binding protein shows bacteriostatic effect and halts bacterial development but it does not show bacteriostatic effect on lactic acid bacteria and streptococcus as they require small amount of iron. The concentration of lactoferrin in colostrum is about 100 fold greater than that of raw bovine milk and ranges from 1.5-5 mg mL^{-1}(Indyk and Filonzi, 2005). Apart from major proteins, 29 minor proteins have been identified in colostrum such as α-antitrypsin, complement C3 α-chain, fibrinogen β-chain, chitinase 3-like 1, apolipoprotein H and gelsolin (Yamada *et al.,* 2002). Non-immunoglobulin proteins present in maternal colostrum are important for development of gastrointestinal tract.

The carbohydrate present in colostrum is known as lactose which consists of glucose and galactose, acts as a source of energy for new born calf. Lactose concentration is low in colostrum and the lowest value reported was 1.2% (Morrill *et al.,* 2012). But it is responsible for nearly half of the osmotic pressure of milk as it causes movement of water from cytosol of mammary epithelial cells into secretory vesicles and then into milk which regulate the milk volume production. Presence of low lactose concentration produces more viscous milk. Besides lactose, some other carbohydrates are present in trace amounts in the form of oligosaccharides which is of two types -neutral and acidic oligosaccharides. Colostrum is the rich source of acidic oligosaccharides and till now 40 oligosachharides have been identified in bovine colostrum with a concentration range varies from 0.7-1.2 g mL^{-1}.

Fat content is higher in colostrum than that of milk with high levels of long chain fatty acids. Because at the time of parturition, cows are in negative energy balance which results in mobilization of fatty acids from adipose tissue that incorporate into milk fat. This, higher level of long chain fatty acids inhibit the de novo synthesis of short-chain fatty acids.

Table 2: Approximate composition of colostrum and whole milk (Ahmadi *et al.,* 2011)

Parameter	Colostrum (1st milking) %	Whole milk (11th milking) %
Lactose	2.7	4.9
Casein	4.8	2.5
Immunoglobulins	6.0	0.09
Fat	6.7	4
Total solid	23.0	13.0
Total protein	14.0	4.0
Mineral	1.0	0.74

Minerals play an important role as the deficiency cause negative impact on growth of calves. The mineral component includes chloride, citrate and phosphate of sodium (Na^+), potassium (K^+), calcium (Ca^{+2}), magnesium (Mg^{+2}) and H^+ which are present either in ionic form or in colloidal form. The most important minerals found in colostrum are calcium and potassium and their concentration is approximately 4-fold and 5-fold higher than milk which give bitter taste. Apart from these macro-minerals, nearly 20 other micro-minerals are also present. The average concentration of copper, manganese, iron and zinc were 1.7 fold, 3.3 fold, 10.7 fold and 10.9 fold higher than milk (Kehoe *et al.,* 2007).

Along with minerals like zinc and magnesium, vitamins are important in supporting the immune defense system of new born calves. Vitamins are two types- water soluble vitamins (vitamin B and C) and fat soluble vitamins (vitamin A, D, E, K). Concentration of these vitamins, are higher in colostrum except pantothenic acid and biotin. Vitamin A found in various form like β-carotene, retinol, retinal and retinoic acid. The deficiency of retinol cause increase chances of diarrhea caused by *Escherichia coli* by decreasing the protective capability of intestinal epithelium. The passive transfer of vitamin E does not occur, rather it shows the mechanism of low density lipoprotein. The calf can't synthesize endogenous vitamin C until 3 weeks of age.

The growth factors present in colostrum are epidermal growth factor (EGF), insulin-like growth factor I (IGF I), IGF II, platelet derived growth factor (PDGF), transforming growth factor β1 (TGF-β1), TGF-β2, betacellulin (BTC), fibroblast growth factor 1 (FGF 1) and FGF 2. The most abundant growth factors present in colostrum are IGF-I and IGF-II. Colostrum also

contains over 20 antibodies to specific pathogens including *Salmonella, E.coli, Streptococcus, Staphylococcus, H.pylori and Rotavirus* that plays a role in body's defence mechanism.

Approximately, 70 indigenous enzymes are present in colostrum like proteinase, lipase, lysozyme, lactoperoxidase, esterase, alkaline phosphatase, acid phosphatase, ribonuclease etc. Lysozyme has germicidal action and the increase in the level of lysozyme is associated with a decrease in the concentration of immunoglobulins. Lactoperoxidase has both germicidal and bacteriostatic properties. Colostrum also contain enzyme inhibitor such as proteinase inhibitor, trypsin inhibitor, bovine plasma elastase inhibitor. Cytokines present in colostrum include tumour necrosis factor (TNF), interferons (INF) and interleukins (IL) that modulate the immune system.

Colostrum feeding

Colostrum accounts for approximately 0.5% of a cow's annual milk output (Scammell 2001). Colostrum should be fed immediately after birth because the absorption of immunoglobulins across intestinal wall is very rapid during first 1-2 hours of life. Even 30 minutes delay in intake of colostrum leads to total decrease in immunoglobulin concentration by about 2 mg/mL. The ability to absorb IgG across the intestinal epithelium diminishes rapidly after birth and ceases by approximately 24hours of age. This is due to rapid postnatal growth which replaces foetal type intestinal enterocytes with adult type enterocytes. Colostrum feeding is a standard practice done @10% of body weight of calves for absorption of immunoglobulin within 6-12 hours of birth without measuring the quality of colostrum. In such cases though the requirement of calf is fulfilled but sufficient quantity of colostrum IgG is not absorbed and serum IgG level becomes less than 10 mg/mL. This condition is known as failure of transfer of passive immunity (FTPI) in calves. FTPI can be a result of inadequate colostrum formation, ingestion or absorption. FTPI itself is not a disease but it is the predisposing cause of diarrhea, dehydration and dullness which increase the morbidity rate, poor growth rate in calves with reduction in production performance. The management factor believed to have the greatest influence on FPT is colostrum volume because if the calf is left to nurse from dam they intake insufficient quantity of colostrum. Depending on the dairy breed, 3 to 4 L is the volume required to deliver an adequate immunoglobulin mass to the majority of calves.

Microbial quality of Colostrum

Bacteria present in colostrum attach to free immunoglobulins in the intestinal lumen and block absorption of these molecules by retarding pinocytosis through enterocytes of lumen, therefore the threshold level for total plate count (<1,00,000 cfu/ml) and Enterobacteriaceae (<10,000 cfu/ml) should be considered (Godden,2008). Provision of high quality colostrum (>50mg of IgG/mL) within first hours of life provide sufficient amount of immunoglobulins in first 30 to 90 days of life. This bacterial contamination has a negative impact on passive immune system of calves. So, proper udder hygiene should be maintained just before collection and sanitation of equipments used during collection, storage and feeding is necessary. Pooling of colostrum must be avoided due to increase chance of disease transmission. Variation in colostrum quality depends upon factors like individual, breed, parity, calving season, dry period length, pre-partum nutrition and post-partum time.

Colostrum quality is affected by breed of cattle. Among the dairy breeds, Holstein has lesser immunoglobulin concentration with greater coliform count and total plate count in colostrum than Jersey (Morrill et al., 2012). The ratio of dry matter, protein, fat and lactose in colostrum

of Holstein- Friesian (HF) cows is 25.8%, 16.6%, 6% and 3.2% respectively. But the density of colostrum is less in Ayshire and Brown Swiss breed than HF cows (Maunsell *et al.,* 1998).

Parity of cow affects colostrum quality. Multiparous cows produce more colostrum with higher concentration of Ig than primiparous cows due to increase incidence of various diseases. Parity 5+ cows had more colostral protein and IgG than first and second parity but the fat and lactose concentration in colostrum decreases with increase in parity (Dunn *et al.,* 2017). Spring calving cows produce colostrum with higher Ig than winter months due to the availability of fresh grass from pasture instead of silage. Also the fat content was greater in spring calving cows (Yaylak *et al.,* 2017). Dry period of cow affect both quality and quantity of colostrum. For regeneration of secretory epithelial cells and lactogenesis process to take place, the dry period should last at least 5 weeks. Cows having dry period of four weeks had higher protein and fat concentration in colostrum but the lactose concentration was higher in colostrym of cows that had a two week long dry period before calving (Kuczaj *et al.,* 2014). Cows supplemented with concentrate 0 to 3 weeks period before parturition had a greater colostral fat concentration than non-concentrate fed cows (Dunn *et al.,* 2017). The concentration of IgG in colostrum was greater in the sample collected <3 hours of post-partum as compared to >9 hours of post-partum (Cummins *et al.,* 2016).

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ENVIRONMENTAL STRESSORS ON FISH

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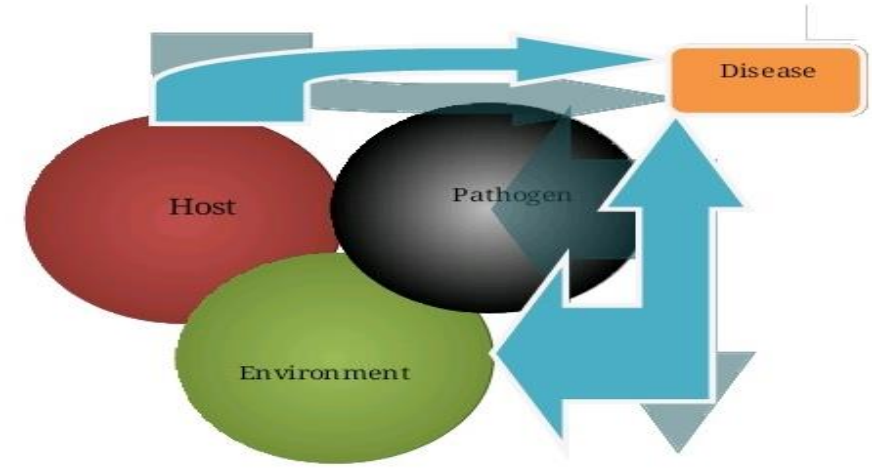
Introduction

Stress The initial contributors to fish sickness and mortality in aquaculture are physiological stress and physical injury. Physical or chemical stimuli that trigger biological reactions that contribute to disease and death are defined as stressors. Many microorganisms that can cause fish disease are constantly present in the water, soil, air, and fish. In nature, fish are often impervious to these infections, and they are willing to seek out the most basic of living conditions. Increased fish density and poor water quality (i.e., low dissolved oxygen, undesirable temperature or pH, increased levels of CO2, ammonia, nitrite, sulphide, organic matter within the water); injury during handling (i.e., capture, sorting, shipping); inadequate nitrite, sulphide, organic matter within the water; inadequate nitrite, sulphide, organic matter within the water); inadequate nitrite, sulphide These conditions may cause the fish to lose their resistance, allowing disease and parasite infestation to spread.



Environment Stress due to Pathogen, Host and Environmental

What is Stress?

- Any condition that causes physical or mental discomfort and causes the release of stress-related hormones or certain physiological responses is referred to be stress.
- Physical, psychological, and environmental stressors are all common.
- Stress can be either brief and acute or prolonged and chronic.
- Mild, short-term stress has minimal negative health consequences, but long-term stress and severe, short-term stress are linked to a number of illnesses and mortality in aquarium fish.

Stress and Its Causes

- Ammonia levels have risen.

- Nitrate levels have increased
- A P_H level that is too high or too low.
- Temperature Changes Improper Salinity
- Low Oxygen
- Treatments with medicine and water
- Other fish Harassment

Water quality

- In ponds and other culture units, don't exceed the carrying capacity of the fish.
- Keep track of the water's quality.
- Maintain dissolved oxygen concentrations of at least 5 mg/L.
- Although not immediately fatal, sub-optimal dissolved oxygen (D.O) levels can stress fish, causing mortality to be delayed.
- Organic trash, nitrogenous wastes (ammonia and nitrite), carbon dioxide, and sulphide should all be avoided.

Transporting and handling of fish

- Use a variety of capture methods that reduce physical injury and stress, such as knitted mesh nets instead of knotted nets to reduce injury and scale loss.
- When it comes to handling fish, haste and gentleness are essential.
- Reduce the number of times the fish are pulled from the water source, and transfer the fish as rapidly as possible.

Nutrition

- Feed a high-quality diet that fits the species' nutritional needs, and use the optimum feeding rate and feeding method (either over-feeding orstarving the fish should be avoided).

Sanitation

- To reduce the risk of transmission, quarantine all new fish, obcontainers, nets, and equipment.
- Send a sample of bedbugs and illness pies from one community to a diagnostic laboratory to be checked for parasites and obversion to viral and bacterial infections.
- Keeping disease-carrying fish out of the hatchery water system is a must (e.g., reservoir ponds, springs, streams).
- Immediately removing all lifeless fish from a production system when they are discovered.

Conclusion

The fish's normal defences against invading infections are weakened as a result of the stress. The underlying stress factors, as well as the disease organism, should be recognised when disease epidemics occur. Chemical disease therapies must be preceded or followed by stress factor monitoring. A disease therapy is just a man-made method of slowing down an illness long enough for the fish's immune system to respond. Any stress that has a negative impact on the fish will result in a disease outbreak. The cost of preventing disease outbreaks is less than the cost of treating dead fish.

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IMPACT OF DIFFERENT GROWTH MEDIUM ON SUNFLOWER SEEDS

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Abstract

Sunflower *(Helianthus annus)* is belonging to Asteraceae family. Helianthus is a genus with 65 different varieties and 14 annual plants. The crop is primarily grown for its edible oil. Sunflowers are also used for a variety of other purposes, including wild bird food, livestock forage, and industrial applications. Dyes for textile industries, medicinal purposes, or garden ornaments. There is a lot of in sunflower. Calcium and other essential minerals. It remove toxins such as lead, arsenic, and uranium from contaminated soil. The sunflower crop was first domesticated in America, and it is now popular worldwide. Sunflower is a multi-branched annual plant with large flowers. Sunflowers have a unique trait known as heliotropism, which means that the bud of the plant always faces the sun, all through the day Sunflowers are naturally allelopathic. It is an excellent option for growers on both on a small and large scale. Helianthus annus, on the other hand, is a low-cost, easy-to-manage investment. Furthermore, it is in higher demand in flower markets. To increase production, various media methods were used. To improve the growth of the sunflower crop, five different media were chosen: sawdust, sand, soil, sawdust and sand, and sawdust and soil. Over a 15-day period, germinated seeds were counted daily. Data on seedling height and number of leaves were collected to estimate seedling emergence from two weeks after sowing to four weeks. Germination began in 8 days, according to the results after sowing for the entire substrate. The highest germination rate was recorded on sawdust substrates, while the lowest rate was recorded on sawdust and sand substrates.

Keywords : Growing media, sunflower, germination, productive, yield, oilseed.

Introduction

The sunflower (*Helianthus annus* L.) is a member of the Asteraceae family. Helianthus is a genus with 65 different varieties and 14 annual plants (Andrew *et al*., 2013). The word Helianthus is derived from helios (the sun) and anthos (a flower), and it means Sunflower, the various times of the day. In general, it is an annual plant with a large inflorescence (flowering head); however, its name is derived from the shape and image of the flower. The plant has rough leaves and circular flower heads (Khaleghizadeh, 2011). Many people make up the head. On a receptacle base, flowers mature into seeds (Seghatoleslami et al., 2012). Sunflower varieties are allergogenic in nature (Fabian Fernandez-Luqueno *et al., 2014*).

Sunflower is the world's fourth largest oil-seed crop, and its seeds and dried stalks are both used as food and fuel. It has been used as an ornamental plant and in ancient ceremonies (Harter *et al*., 2004; Muller *et al.,* 2011). Furthermore, medical applications for pulmonary diseases have been discovered. uncovered Furthermore, parts of this plant are used to make dyes for the textile industry, body paint, and cosmetics. Painting and other embellishments Sunflower oil is used in salad dressings, cooking, and cosmetics. Production of margarine and shortening (Kunduraci *et al*., 2010).

Sunflower is the fourth largest oil-seed crop in the world, and its seeds and dried stalks are used as both food and fuel. Medical applications for pulmonary diseases have also been discovered. Discovered Parts of this plant are also used to create dyes for the textile industry, body paint, and cosmetics. Painting and other ornamentation Salad dressings, cooking, and cosmetics all make use of sunflower oil. Manufacturing of margarine and shortening (Kunduraci *et al*., 2010).

Uses

Edible oil

Sunflower seed oil content ranges from 39 to 49 percent in commercially available varieties. In 1985-86, sunflower seed was the world's third largest source of vegetable oil, trailing only soybean and palm. Sunflower accounts for approximately 14 percent of global seed oil production (6.9 million in 1985-86) and approximately 7 percent of total seed oil production. Oil cake and meal made from oilseeds Sunflower oil is widely regarded as a premium oil because of its light colour, high unsaturated fatty acid content, lack of linolenic acid, bland flavour, and high smoke points (Singh, A., *et al.*, 2021). The primary applications are as a salad dressing, cooking oil, and in margarine. It has expanded the use of sunflower oils for frying, tends to increase the shelf life of snacks, and could be used as an ingredient in infant formulas that require stability.

Meals

Sunflower meal has more fibre, a lower energy value, and less lysine but more methionine than soybean meal. Sunflower meal protein percentages range from 28 percent for non-decupled seeds to 42 percent for completely decupled seeds. Depending on the extraction process and degree of dehulling, the colour of the meal ranges from grey to black.

Industrial applications

Sunflower oil is commonly used in the production of soap and detergents. Sunflower oil has been investigated as a pesticide carrier and in the production of agrochemicals, surfactants, adhesives, plastics, fabric softeners, lubricants, and coatings. This application's utility is typically. Depending on the price of petrochemical feedstock. Sunflower oil contains 93 percent of the energy in the United States. Number 2 diesel fuel, and considerable effort has been expended to investigate the potential of sunflower as a biofuel a substitute fuel source in diesel engines.

Non- oil seeds

Over the last 15 years, the use of sunflower seed for birdfeed or as a snack in human diets has steadily increased. Varieties used for non-oil seed purposes have larger seed sizes and require slightly different management practices (Singh, A., *et al.*, 2021). During processing, seed is divided into two types: 1. larger seed for shell roasting and smaller seed for other uses. 2. Large for dehulling, 3. Small for birdseed. The standards for various uses differ depending on the application.

Forage

Sunflower can also be used to make silage. It can be used as a double crop after early harvesting of small grains or vegetables, as an emergency crop, or in areas where the growing season is too short to produce mature corn for silage. Sunflower silage has a higher nutritional quality than corn silage.

Characteristics

Sunflowers attract bees, making them useful in areas where beekeeping is practiced, and more bees are desired. Sunflower petals are not all yellow. There are over 60 different types of sunflowers that can be found all over the world, some of which have striped petals. Some sunflowers have different interiors as well nuances. The French word for sunflower is turnsole, which literally translates to "turned sun. "The ability of the plant to turn itself to face the sun. The sunflower is the only flower whose name includes the word "flower" (Colleen Vanderlinden, 2020).

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Different Growth Medium

Sr. No	Treatment	Material used
1	T1	Sawdust
2	T2	Sand
3	T3	Soil
4	T4	Sawdust + sand
5	T5	Sawdust + soil

Fig.1 : Different growth medium.

These distinct treatments were used to forecast better sunflower crop growth. These treatments were carried out over a 20-day period for seed germination, resulting in seedlings with a minimum shoot height of two millimeters. The parameters that were considered on different mediums are seed germination, the impact of substrate on seed germination, and the effect of substrate on seed germination. seed germination and sawdust's effect on seed germination.

Effect of substrate on seed germination

The germination rates for all substrates were less than 90% two weeks after sowing, with sawdust substrate having the highest germination rates. Germination was significantly faster on sawdust and soil than on sand.

Based on the germination rate, the substrate are as follows: Sawdust> soil> sand> sawdust+ sand> sawdust + sand.

Effects of sawdust on seed germination

Sawdust as a component of crop growth media. Furthermore, it has good air-filled porosity and low contact of available water, but this is affected by particle size. The primary effect of sawdust was a significant increase in plant height. The greatest increase in the increase in plant height observed in this treatment could be attributed to an increase in available phosphorus and other nutrients. Dietary supplements Phosphorus promotes cell division in the plant height during vegetative growth expansion.

Conclusion

For a period of 15 days, germinating seeds were counted daily. Data on seedling height and number of leaves were also collected to estimate seedling emergence from two weeks after sowing to four weeks after sowing. Germination began in all substrates 8 days after sowing, according to the results. The very best Germination rates were highest on sawdust substrates and lowest on soil. The seedling on the maximum number of leaves on sawdust substrates was five.

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MUTATION BREEDING AND ITS ROLE IN CROP IMPROVEMENT

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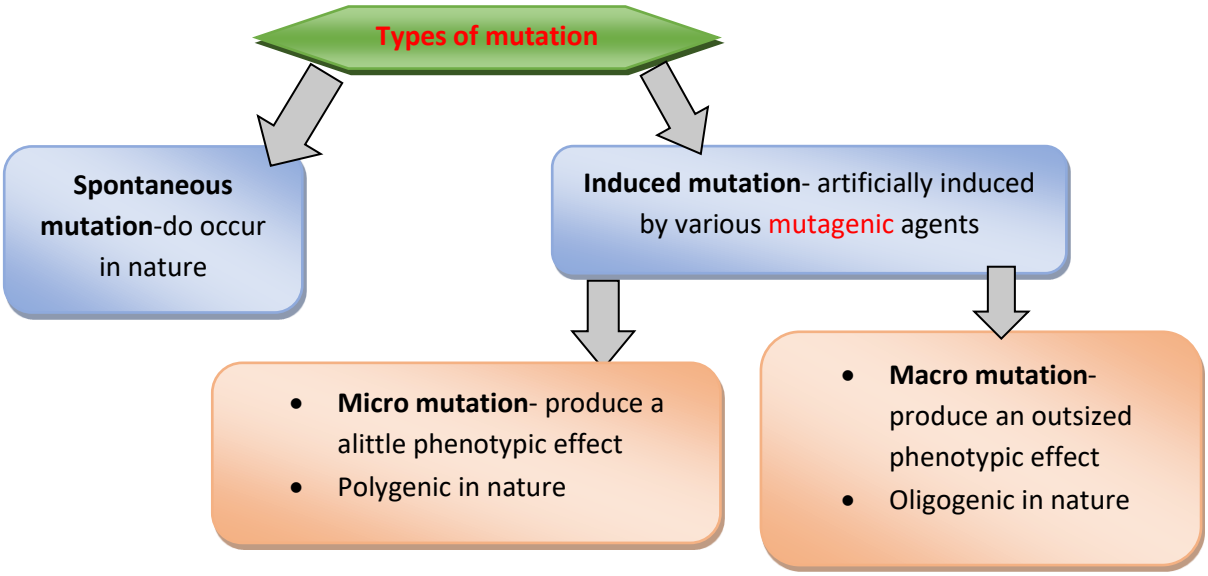
Introduction

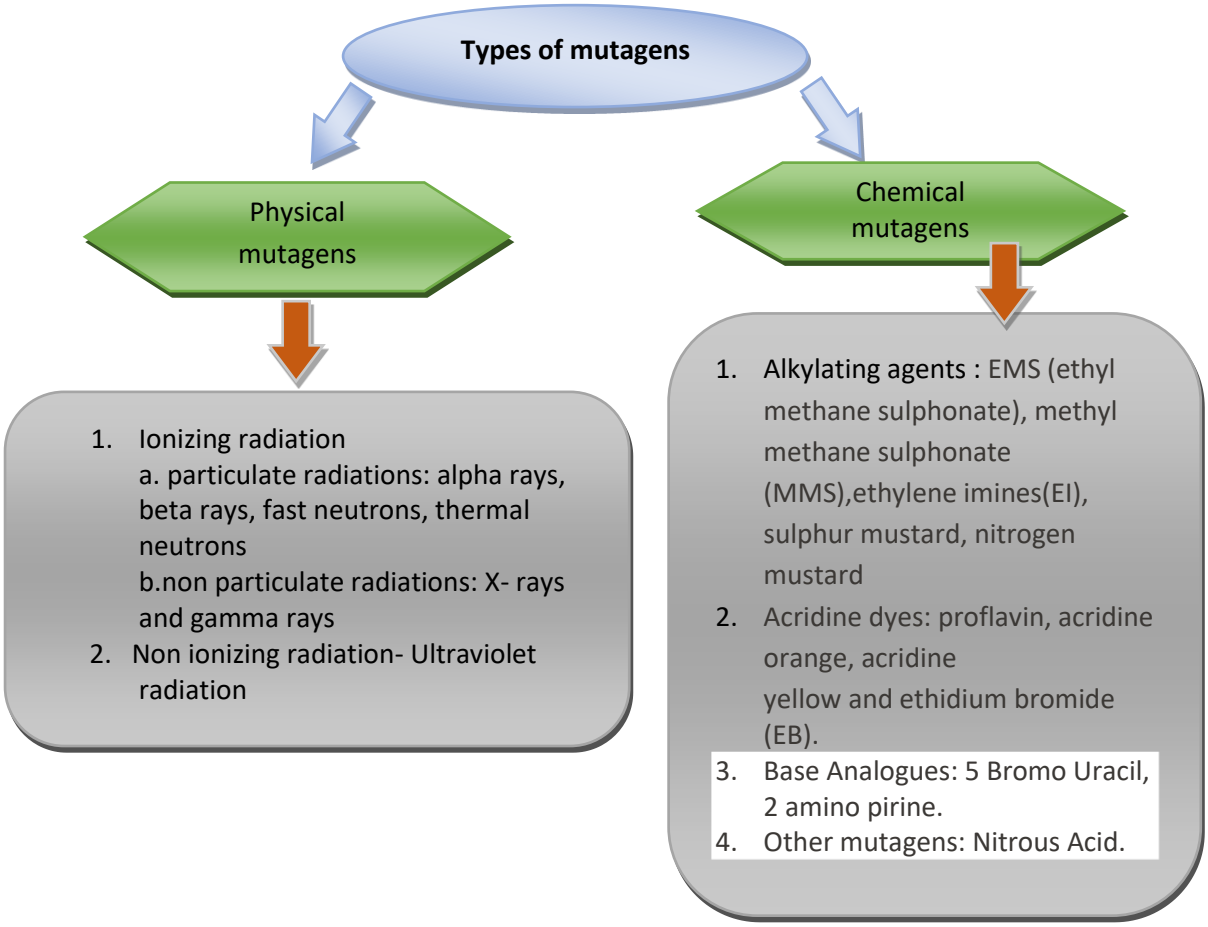
Sudden heritable change within the phenotype of an individual is known as mutation. Within the molecular term, mutation is defined because the permanent and comparatively rare change within the number or sequence of nucleotide. In other words, mutations arise caused by change in DNA bases. Mutation breeding sometimes mentioned as variation breeding, is that the process of exposing seeds to chemicals or radiation so as to get mutants with desirable traits to be bred with other cultivars. Plants obtained through mutagenesis are sometimes called mutagenic plants or mutagenic seeds.

Mutation

Sudden heritable change in the phenotype of an individual is called as mutation.



MUTAGENS : Mutagen may be a physical or chemical agent that permanently changes genetic material , usually DNA, in an organism and thus increases the frequency of mutations above the natural noise level.

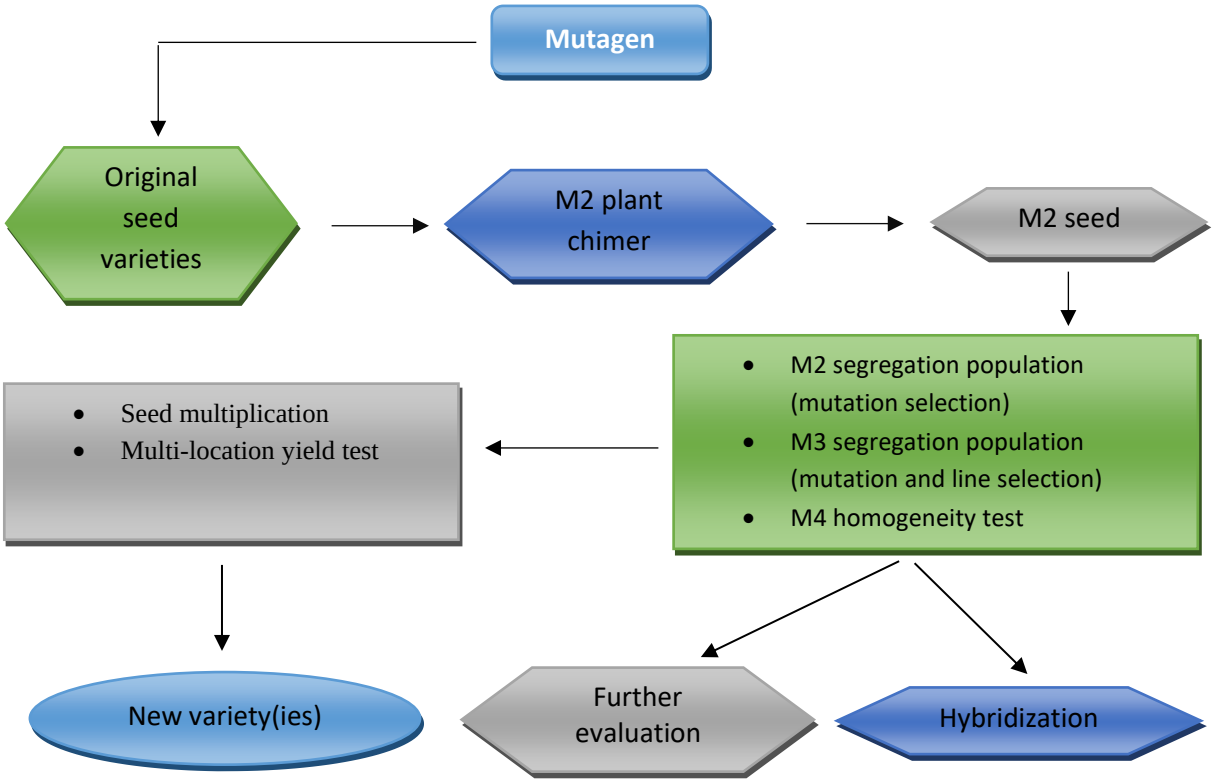


What is mutation breeding?

Mutation breeding is that the deliberate induction and growth of mutant lines for crop improvement. Its most ordinarily utilized in asexually propagated crops and self pollinated crops.

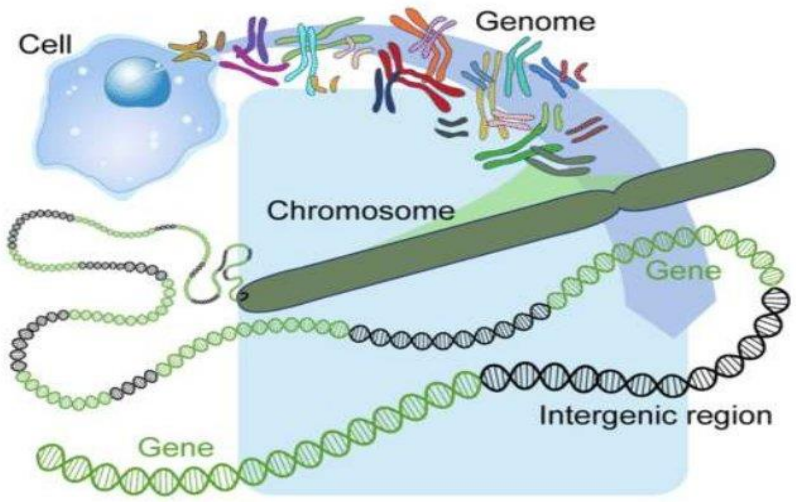
Natural selection operates to cause about evolution of latest races and species through the variability created by natural mutations and amplified by subsequent recombination of genes during amphimixis. Besides natural mutations that occur spontaneously caused by various sorts of radiations and cosmic rays received from the sun and also emitted by several radioactive elements, mutation also can be artificially induced by a variety of physical agents like gamma rays and X-rays and number of other sorts of chemical agents belonging to few specified groups referred to as chemical mutagens. And using an equivalent effectively through elaborate method of selection techniques in various generations for improvement of a specific crop species for desired objectives is named mutation breeding.

Method of mutation breeding



Role of mutation breeding in crop improvement

- Development of improved varieties: in India improved varieties are developed through mutation breeding in wheat, rice, barley etc. Besides high yield , varieties with better quality, earliness, dwarfness, disease resistance and low toxin contents are developed in various crops.
- Induction of male sterility: GMS has been induced in durum wheat and CMS induced in barley. Its reduces the value of hybrid seed production.
- Creation of variability: induced mutations are used for increasing the range of genetic variability in barley, wheat.
- Improvement in adaptation: Induced mutations play an crucial role in improving adaptation of some crops.



Future Prospects

In recent years in vitro mutagenesis technique has enhanced the crop yield and germplasm innovation by the event of quality and improved resistance traits. In in vitro culture techniques, a little amount of tissues and calli can be subjected to mutagenesis for the betterment of crop species. Currently, the utilization of in vitro mutagenesis is low, little or no number of plants like banana and sugarcane are regenerated through this technique.

On the other side, many seed propagated plants such as wheat, rice, maize and barley can now be regenerated from cell suspension cultures. In future expansion of in vitro cell selection techniques for disease resistance would be equally important. A coordination of the recent techniques of anther and microspore culture, cell suspension, irradiation of haploid cells and chromosome doubling and regeneration of doubled haploid plants might be utilized to get genotypes with desired traits. The induced mutation has also proved useful within the preparation of genetic maps which will facilitate molecular marker assisted plant breeding in future.

Mutation breeding has become increasingly popular in recent times as an efficient tool for crop improvement . The direct use of mutation in the growth of molecular maps in structural and functional genomics could lead to rapid improvement of plant yield and quality. The molecular techniques of DNA fingerprinting and molecular mappings like RAPD (Random Amplified Polymorphic DNA,) AFLP (Amplified Fragment Length Polymorphisms) and STMS (Sequence-Tagged Microsatellite Sites) have contributed significantly in the screening and analysis of mutants. Site directed insertion of transgenes supported chimeric RNA/DNA oligonucleotides as done in tomato and maize and mutant tagging are going to be widely used in gene technology.

Varieties developed in india through mutation breeding

Crop	Varieties	Special character
Wheat	Sharbati sonara NP 836	Semi dwarf non-lodging mutant variety
Rice	Jagannath	Bold seed size
	Prabhavati	Short stature
	Mohan	Salt tolerance variety
Cotton	MA-9, MCU-7, Pusa ageti	Salt tolerance variety
Chickpea	Pusa 408, Pusa 413, Pusa 417, Pusa 547	Ascochyta blight, Fusarium wilt resistance Bold seeds, better cooking quality Bold seeds, better cooking quality and high yield performance
Mung Bean	Pant Mung-2	high yield performance
Barley	RDB-1	Short stature
Groundnut	TG 47 TBG 39	Large seed and early maturity High oleic acid

Conclusion

At present genetic variability is narrowed using conventional breeding approaches for a long period, induced mutagenesis are one among the foremost important approaches for broadening the genetic variation and variety in crops to bypass the bottleneck conditions.

Induced mutagenesis, although almost a seven decades old technique, demonstrably can contribute to unleashing the potentials of plant genetic resources and thereby avail plant breeders the raw materials required to get the envisaged smart crop varieties. Crop varieties obtained through the exploitations of mutation breeding are significantly contributing to global food and nutritional security and improved livelihoods.

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REPLACEMENT OF CASHEW NUT ORCHARDS BY FERTILIZER RESPONSIVE RUBBER PLANTATION; AN ALARMING SITUATION IN GARO HILLS REGION OF MEGHALAYA

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Cashew, a perennial tree that is well known as "poor man's crop" is a source of highly-priced cashew nuts. India is the leading producer, consumer, and the second-largest exporter of cashew in the world. It has a prime position in cashew trade in the world market. Cashew is cultivated largely as a neglected crop, it ends up as a favorite snack food all over the world. In India, cashew is cultivated mainly in Kerala, Karnataka, Maharashtra and Goa along the West Coast, and Tamil Nadu, Andhra Pradesh, Odisha and West Bengal along the East Coast region (DCR, 2011). Cashew cultivation in major growing states receives dwindling importance in response to the price fluctuations in areca nut, cocoa, rubber and coconut. Cashew cultivation is a technically feasible, financially viable and bankable activity based on agro-climatic conditions. The Garo Hills region of Meghalaya is well known for its horticultural crop production due to its suitable climatic condition, and soil status. The region is dominated by Garo tribal people and the majority of the farmers in the village areas have cashew nut, areca nut, black pepper, and betel vine orchard. Many farmers of this region are dependent on plantation crop. In Garo Hills, cashew production was 14815 metric tonnes covering 10461 ha area with productivity of 1416 kg per ha during 2017-18.

Cashew being tropical crop can tolerate higher temperatures but is highly sensitive to frost. The optimum temperature range for successful cultivation is about 20°C to 30°C. The annual precipitation of 1000 to 2000 mm is ideal for cashew plantation. The coincidence of flowering with high rainfall or excess humidity leads to the incidence of pests and diseases. Clayey soils with poor drainage and soils with pH more than 8 are unsuitable for the crop. Red sandy loam, lateritic soils with slightly acidic to neutral pH are best suited for cashew cultivation.

Cashew nut production plays a pivotal role in fostering and sustaining the tempo of rural development. In West Garo Hills, grading and packing of raw cashew nut is done by village merchants, wholesalers and processors. The highest cost is incurred by the whole seller ((₹ 200/q) followed by village merchant (₹ 70/q) and processor ((₹ 60/q).The highest benefit-cost

ratio was achieved by the large farms because of judicious expenditure in cashew production and obtaining a sizeable amount of returns.

Cashew nut cultivation is the main source of livelihood for many growers in the region but a large section of them have shifted to rubber cultivation in the last few years due to dwindling prices and high investment in cashew nut cultivation. Now a day, many growers are transforming their existing cashew nut orchard to rubber plantation due to decreased production and productivity. The Garo Hills lies in a heavy rainfall area, and the practice of *jhum* cultivation has led to large scale soil erosion in many areas due to which several cashew trees of this area had exposed roots and farmers face loses. Here, rains start in the early April and continue till first week of October with high speed of winds, hailstorm and cyclone resulting in cashew crop damage.

Factors affected in cashew nut production

- With the increase climate change situation, the cashew growers experienced the problems of high infestation of pests and diseases.
- High input cost, scarcity of labour and poor quality of planting materials also discourage the cashew growers.
- Nuts get dry after the harvest. The farmers generally pick up the fallen nuts and sell to the local cashew traders at variable existing price which is most of the time minimal due to middleman.
- Lack of backward linkages between farmers, processors and longer chain intermediaries has resulted in a lack of adequate economic benefits to farmers.
- This drop-in productivity, coupled with fluctuating prices, is forcing cashew farmers in the major cashew growing regions to shift to more remunerative cash crops (Ganapathi and Akash, 2013; Sajeev et al., 2014a,2014b & 2015; Sajeev and Saroj, 2015, 2018; Venkattakumar, 2006 & 2008).
- Value addition is almost non-persisting or non-existent. Among other factors, lack of suitable preservation methods at the farmer's end further aggravates the losses.
- Post-harvest loss due to mishandling, non-hygienic practices, immature harvesting, etc. has also been constraints for the farmers in the way of getting a good price of the produce.
- Poor marketing facilities and no processing units are one of the major problems faced by cashew growers, for which they are not getting remunerative prices.

Reasons for adoption of rubber plantation in a cashew nut orchard

- Rubber tree provides quick income to the growers after formation of latex in the tree. Many argue that rubber provides longer term employment and land rights.
- No problems of marketing, they can sell the product to local middle man or nearby processing units with a higher price than cashew.
- Providing income round the year to the growers up to 7-8 years.
- It requires very little care and management after plantation.
- The high demand of the latex in the market or by the industry.
- Rubber industries are motivating and providing good support to the growers, results growers are taking more interest in it.

Threats to rural tribal farmers on increasing area under rubber plantation

- Most of this rubber plantation is monoculture — growing only one plant species in an area. Scientists term monocultures as “biological deserts” because unlike natural forests, they don’t house diverse plant and animal species.
- Rubber plantation reduces biodiversity, water reserves and soil productivity.
- Rubber plants require 60-80% more water in comparison to other plants in a forest.
- Rubber plantation can cause hindrance in performing agricultural operations and ultimately damage other existing crops.
- Rubber plantation reduced the water level of that particular growing area to many years.
- No other crops can be cultivated in the rubber plantation area because it makes soil hard and unfertile.

Future scope

- Cashew in Garo Hills region of Meghalaya is found to be economically feasible which can be made more beneficial by reducing the cost of production through the intervention of modern techniques in cashew cultivation.
- Direct Marketing of cashew produce will fetch a good price for the producer but it is not possible for all categories of farmers. Therefore, the formation of a cooperative society of cashew growers is suggested for procuring various inputs as well as the marketing of produce of the member farmers.
- Since there is great demand for Indian organic cashew kernels, Garo Hills region can be developed as an important region for growing cashew organically with establishment of processing units in rural and urban areas.

Recommendation

- Majority of the farmers of Garo hills region are resource-poor and unable to afford the input costs as well as the production cost of cashew products. There is no any established input retailer shop, where farmers can procure a high yielding variety of seed/ planting materials. Therefore, financial support is necessary for cashew farmers through exclusive credit facilities.
- Strengthening of linkage between growers and various agencies will enhance the operational marketing efficiency through intervention of post-harvest technologies like grading, sorting, packaging, etc. as well as enhance cashew producer and consumer price.

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PESTICIDES USE IN AGRICULTURE : AN ISSUE THAT NEEDS TO BE ADDRESSED

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Introduction

Pesticides belong to a category of chemicals used worldwide to prevent or control pests, weeds, plant pathogen, and diseases to eliminate or reduce yield losses so that high rate of product quality maintained. The positive scenario of using pesticides is that it resulted in enhanced crop productivity and there are reports which suggests that there is massive reduction in diseases which has originate vector-borne origin. Chemical pesticides can be classified according to their chemical composition. This method allows the uniform and scientific grouping of pesticides to establish a correlation between structure, activity, toxicity and degradation mechanisms, among other characteristics. There are different types of pesticides which fall under different category **(Table 1**) and has different feature according to their source of parent compound and some properties are, i) Pesticides guards the crops against weeds, insects, pests and other fungi, ii) one other very important feature regarding pesticides is their persistence and it has been observed that some cheaper and older pesticides can persists in soil and water for years. These chemicals have been banned from agricultural use in developed countries, but many developing countries still using these pesticides and they posse's potential toxic threat to humans and can cause both chronic and acute health related issues which directly under the influence of exposure time in which a person exposed to these toxic pesticides. The main problem of using pesticides in agriculture is its toxic nature and long persistence in environment and these problems need to be fixed for sustainable use of pesticides in future.

Table 1. General classification of pesticides

Pesticides	Characterstics	Example
ORGANO CHLORINE AND ORGANO PHOSPHATES	Soluble in lipids, get accumulated in fat tissues of animals, and transmit via food chain; posses toxicity to a variety of animals.	Malathion, methyl, DDT, chlordane, aldrin, lindane, mirex, parathion.
CARBAMATES	Carbamate kind of acid derivatives that has limited spectrum toxicity to insects, but highly toxic to vertebrates.	Sevin, carbaryl
PYRETHROIDS	It directly effects nervous system but has less persistent as compared to other pesticides.	Pyrethrins
BIOLOGICAL	*Bacillus thuringiensis* (Bt) and its subspecies are commonly used against pests specially to butterflies and caterpillars.	Dispel and thuricide

Global impact and WHO response

The United Nations Population Division estimates that, by the year 2050, there will be 9.7 billion people on Earth – around 30% more people than in 2017. Nearly all of this population growth will occur in developing countries. FAO (Food and Agriculture Organization) of the United Nations estimates that, in developing countries, 80% of the necessary increases in food production so that they can keep the pace of food production rate with population growth rate and the same pressure will now be there lands to increase crop production. Pesticides can prevent large crop losses and will therefore continue to play a role in agriculture. WHO, has been working in collaboration with FAO, and these two organizations seems to be responsible for assessing potential risks threat to humans by pesticides – that involves both direct exposure to pesticides, and via pesticides residues that remained in food – and for recommending adequate protection. To address the issue of having pesticides residues in food a separate independent body has been developed that consist of experts from international scientific groups and called JPMR (Joint FAO/WHO Meeting on Pesticide Residues).

Effect of pesticides

There are number of pesticides which are harmful to the humans and responsible for many disease and some of them are listed below, although fate of pesticides are generally depends upon the process it will undergo **(Figure 1)** but some prominent pesticides are, i) **Paraquat, a pesticide linked to Parkinson's disease**, is banned in China and the European Union but not in U.S.A. It's highly toxic and kills weeds on contact. A 2009 UCLA study found that a person exposed to paraquat and two other pesticides is three times as likely to develop Parkinson's disease, ii) **A volatile and toxic pesticide called 1,3-D (1,3-Dichloropropene) is one of the most heavily used pesticides in California** also known as Telone, the chemical is actually a gas, or a fumigant in pesticide speaks and thus diffuse readily in environment and can cause cancer, iii) **Glyphosate, the active ingredient in Monsanto's roundup** Ontario, Canada, banned it for home use as a "cosmetic" pesticide (chemicals that keep your yard looking nice). Srilanka also banned the use of glyphosate as scientists suspect it may be the culprit in widespread kidney disease among agricultural workers in Sri Lanka, India and Central America, iv) **A popular herbicide called atrazine is the pesticide most commonly found in American drinking water and due to this** European Union banned this pesticides in 2004 but the EPA (Enviromental Protection Agency) re-evaluated it and allow the further use of atrazine use in 2009.

Pesticide remediation strategies

Due to persistence nature of pesticides in an environment and their toxic nature is now becoming a major threat and to counter these effective clean- up of residual pesticides from polluted site is very important and to achieve that development of new and innovative technologies should be applied that guarantee pesticides elimination from a site in a very safe, economical and in an efficient manner. Ideally, use of these new technology must result into destruction of parent compound without being generating so much intermediates compounds. However some major measures that have been taken to remove pesticides are as follows;

1. Thermal desorption (at low temperature)

This is an *ex situ* clean up technology that has been frequently used to decontaminate polluted pesticides sites via thermal desorption. But to carry out thermal desorption we need highly specialized equipments facility which may not be cost efficient. In this process volatile

and semi-volatile compounds are taken from sites that includes residual pesticides and further involves heating of substrate at high temperature e.g. between 300 to 1000°F, which causes volatilization of compounds.

2. Incineration

Incineration is another very well proven and one of the most frequently used technology to remediate pesticide from contaminated sites. Unlike thermal desorption inceneration caused complete destruction of pesticides contaminant from the sample. Samples such as soil, sediments or sludge which are rich in high organic contaminants have been efficiently removed by incinerator that involves high temperature e.g. between 1,600 to 2,200°F.

3. Phytoremediation

Phytoremediation is very cost-effective and aesthetically-pleasing process that is used to treat the pesticides contaminated (U.S. EPA, 1999, 2000). Phytoremediation involves the natural ecosystems, in which the intermediates generated during process are being metabolized by plants, and in this technology plants act as filters. Phytoremediation involves used to remove pesticides contaminant from water and soil (Raskin et al., 2000). Example- Ethion phytoremediation , it is a phosphorus pesticide which was studied with water plant hyacinth; *Eichhornia crassipes* (Huilong el al., 2006).

4. Biodegradation of pesticides

Bioinoculatants are also plays a very important role in remediating pesticides. There are many bacterial strains that are being reported to remove pesticides contaminant but fungi seem to have a very potential to bioremediate pesticides contaminant. Isolation of potential fungi from a natural source is first step and which later screened for its biodegradation ability of pesticides. For example, wood attacking fungi e.g. Phanerochaete possess a potential extracellular enzyme (Peroxidase) that seems to act on the broad range of parent compounds that are very similar in nature as pesticides.

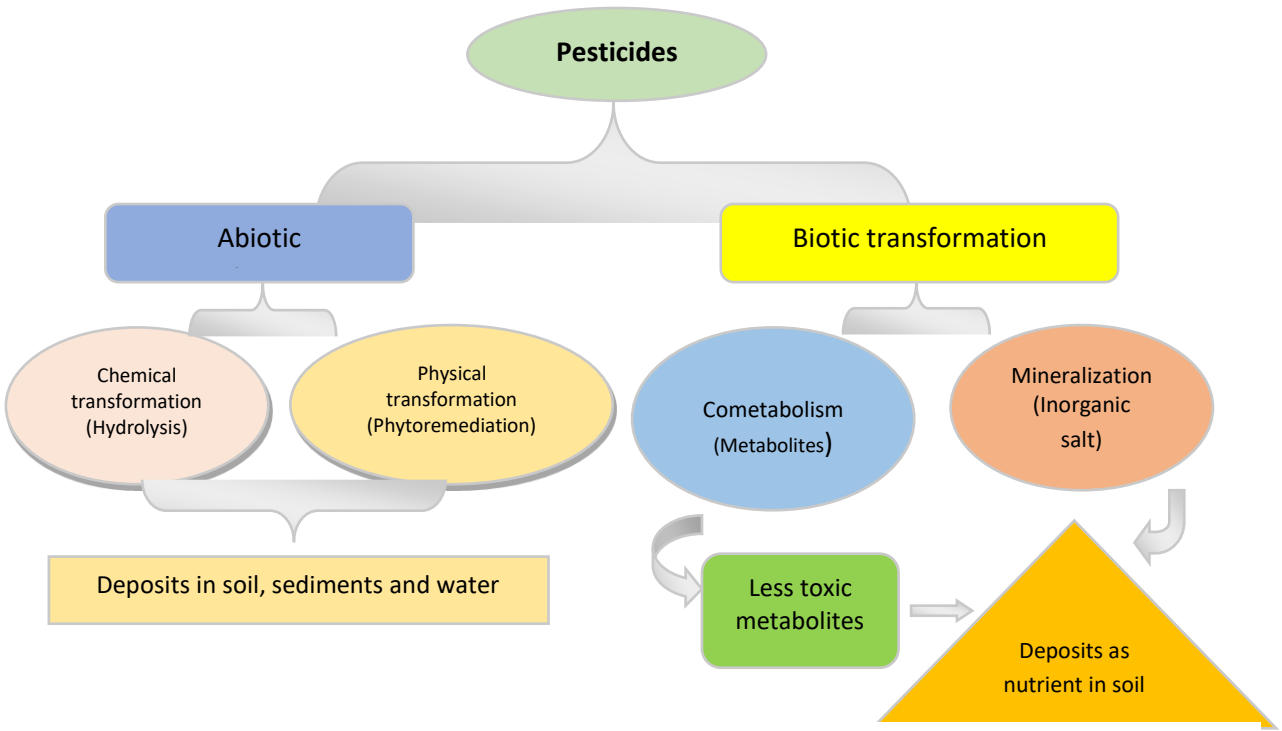

Figure 1. Fate of pesticides in an enviroment

Conclusion and future and prospects.

The role of pesticides in agriculture are unparalled but these advantages came up with some serious issue like risk involved in human and environment health and these issue are needed to be check out in a serious manner.

In future planning several techniques are being used to remove residual pesticides contaminant and need some more modification so that pesticides are much more safer to use.

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SCOPE OF BRASSICACEAE PLANTS AS POTENTIAL BIOFUMIGANTS FOR THE MANAGEMENT OF THE ROOTKNOT NEMATODE IN VEGETABLES PRODUCTION - A REVIEW

Akkabathula Nithish

Abstract

Biofumigation is that the practice of using volatile chemicals released from decomposing material to suppress soil pathogens, insects and germinating weed seeds. It has been used as an alternative to methyl bromide and other synthetic pesticides in horticulture and agriculture in general. Biofumigation use plant material and naturally produced compounds and is an increasingly feasible method of pest management. This pest management technique is an eco-friendly potential tool adopted to suppress the pest in the soil. Brassicas are mainly used for biofumigation to manage root-knot nematodes. The decomposition of the plant tissues in these families releases glucosinolates that break down into nematotoxic isothiocyanates which are biocidal. The potential of biofumigation have increasingly explored by research endeavors. However, there is need for research into brassicas that can be used for biofumigation. There is also a need for research on methods of incorporating the biofumigant plants into the soil. Breeding for brassicas with high isothiocyanates content also has got to be done. There should even be effort to teach farmers about biofumigtion since most farmers aren't conscious of this system. The reaction of target pests, the choice of biofumigant and ideal environments for efficacy is still to be evaluated.

Keywords : biofumigation, root-knot nematode,*Brassicaceae*.

Introduction

Nematodes are the most widely dispersed phylum of multicellular animals. While many are free living and have little to no impact on plant health, some species have adapted to parasitize plants. They often present an intractable problem especially to smallholders in the tropics and subtropics. They are the "hidden enemy" and the damage they do go unrecognized because the symptoms above ground are not specific and the pests are not visible to the naked eye. Nematode predation is difficult to trace due to the nature of the pest in causing the damage. They cause extensive damage to a wide variety of economically important crops (Sasser, 1980) and remain as one of the most serious pest faced by vegetable growing farmers. They are of great importance both in terms of their damage to crops and the difficulty of their control. The control of the pest has little chance of success and is uneconomical because they mostly live inside the soil and feed on the internal plant tissues. Annual yield losses on worldwide scale that are attributed to plant-parasitic nematode are estimated to range between 5% to 12% (Sasser and Freckman, 1987) reducing production by millions of tones every year. Depending on climate, crops grown, nematodes density levels, and economic factors, a number of tactics can be employed to minimize nematode damage (Ploeg 2008).

Of plant parasitic nematodes, Root-knot nematodes are a group of semi-sedentary endoprasitic nematodes which are considered as one of the most important species in terms of both its worldwide geographical distribution and very large host range, reaching up to 3,000 different plant species (Lamberti, 1979) is a major limiting factor in vegetable

production. They are economically damaging nematodes on a range of crops in subtropical and tropical climates (Koenning *et al*. 1999; Stirling and Stirling 2003) which form specialized feeding cells in the roots of their host plants and utilize the photosynthate produced in leaves for their energy needs (Kochba and Samish, 1971). As a result of such parasitism, root weight increases while shoot weight declines (Fortnum *et al*., 1991) leading to crop losses of around 15% in tropical countries (Sasser 1979). They are almost always present to some extent in agricultural soils and their populations increase to damaging levels when susceptible hosts are grown on the same land for many years. Crops also become much more susceptible to the effects of nematodes under adverse conditions of poor soil fertility or moisture stress (Hillocks 2002). Moreover yield losses of 50-80% caused by these nematodes in vegetable crops are common (Siddiqi 2000). Symptoms of root-knot nematode attack include formation of galls on the roots and wilting of the upper parts of the infected plants. Moreover, soil-borne pathogens can more easily penetrate in roots infected by nematodes, thus causing damage superior to the one caused by the nematode itself.

Nematodes can be controlled by using chemical nematicides, but the range of available compounds is limited, expensive and their uses have negative impacts on the environment and on public health. Most chemical nematicides are either less effective or too expensive and related to a negative impact on the environment and public health (Braun and Supkoff, 1994). In addition, “the impacts of many pesticides on the environment and human health are currently being re-evaluated” (Obenauf, 2004). So there is increased interest in non-chemical nematode management strategies. As a result, there's growing interest in alternative methods of management that are economically viable and non-polluting. an alternate management strategy that's receiving increased interest is fumigation. In the past decades soil fumigation with methyl bromide has been the most common method of nematode control (Abou-Jawdah *et al*., 2000) and was almost exclusively used throughout many years. However, despite of its efficiency in controlling of a good range of soil borne pests and pathogens in high-value horticultural crops, this fumigant was found to be together of the foremost powerful Ozone Depleting Substances (ODS). Due to increasing environmental concerns, in 1997 parties of the Montreal Protocol for the protection of the Ozone layer agreed to phase out Methyl Bromide and replace it with safe and viable alternatives throughout the world. In recent years the phasing out of methyl bromide has the effect of bringing into sharp focus the need for alternative strategies for the management of soil borne pests and diseases, not just for users of methyl bromide but in a general senseis becoming imperative necessity.

Biofumigation

Biofumigationcan be defined as a sustainable agronomic practice by using naturally produced plant compounds for managing soil pests. It may work as a stand-alone treatment or in combination with other strategies such as sanitation, organic amendments, or solarization (Wang *et al*. 2006; Collange*et al*., 2011).The first scientific article on biofumigation was published by Angus *et al* in 1994. It was defined by several researchers (Halberendt 1996; Kirkegaard and Sarwar 1998) as a process that occurs when volatile compounds with pesticidal properties are released during decomposition of plant materials or animal products. This practice primarily relieson volatile organic compounds when they or their byproducts are incorporated into soil by ploughing of above and below ground biomass residues to breakdown into secondary compounds. Therefore, soil biofumigation with the use of crops become the alternative in the production of vegetable crops. Some chemicals produced by

certain plants have the potential in managing some pests and nematodes (Oka *et al*., 2006). A systematic approach to research into biofumigation with green manures should aim at overcoming a long history of empiricisms in recent advances in both basic and applied knowledge. Therefore, more emphasis is currently put in the development of environment friendly, efficient and sustainable alternative techniques (Katan*et al*., 1976).

Brassicaceae plants as biofumigants

Brassicas are able to produce about 30 to 40 different Glucosinolates which when combined with other factors negatively effect on the appearance of soil pests and diseases. Brassicaceae plants primarily grow in temperate regions and prefer deep, well-drained soils. They are less tolerant to heat when compared to many other plant families (Björkman *et al*. 2011). In the past decade, for the control of soil fungi, nematodes and other soil borne pests in sustainable vegetable production systems interest was shown towards growing cover crops in general and Brassicaceae plants as green manures (Lazzeri*et al*., 1993; Buskov*et al*., 2002; Davis *et al*., 1996). Many studies indicate that plants of the Brassicaceae family have the potential of replacing fumigant nematicides by releasing chemicals which suppress the nematodes in the production of a large variety of crops. However, most research on biofumigation has been focused by using brassicaceous crops (Kirkegaard and Matthiessen, 2004).

The suppressive effect of brassicaceous biofumigants on soil borne pathogens, weeds and plant-parasitic nematodes has been demonstrated in numerous laboratories, greenhouses and in field studies (Ploeg and Stapleton, 2001; Ploeg, 2008; Zasadaet al., 2010) and has been found that the biocidal activity of these plants is due to the presence of certain organic compounds in their cells called glucosinolates. Upon tissue disruption, a number of toxic products like thiocyanatesand isothiocyanates are known toreleased from these compounds during decomposition (Chew 1988; Brown *et al*. 1991)which are chemically similar to the active agent of methyl bromide. When provided with adequate moisture, Brassica varieties with high glucosinolate suppress soil borne pests by the releasing isothiocyanates in the soil (Morra and Kirkegaard, 2002). Among many Brassica plants, arugula (*Eruca sativa*) possesses biofumigant and trap crop qualities, and it has recently gained popularity as a potential alternative to Methyl Bromide.

In the past years extensive research has been carried on the efficiency of biofumigation for the management of plant parasitic nematodes on plants of the Solanaceae family, which have a particular degree of resistance or tolerance towards nematodes. Biofumigation with the use of green manure crops of the Brassica family is an effective management practice to reduce populations of plant parasitic nematodes. Thus plants of Brassica family have the potential to replace fumigant nematicides (Mojtahedi*et al*., 1991; McFadden *et al*., 1992; Spak*et al*., 1993). However, a far better understanding of the real effects of green manure crops on the root-knot nematodes is required so as to elaborate improved management strategies. Since biofumigation is a recent non-chemical plant protection management practice, very little information is out there on the applicability of this practice for the production of vegetable crops and efficacy on nematode management.

Conclusion

The intent of this review is more than a repetitious description of the history and mechanisms of the concept of biofumigation as a potential control method in root-knot nematode management. In view of environmental and human health risks, biofumigation is an attractive alternative. For farmers who had already applied organic matter or who grew cover crops,

the switch to biofumigation to control nematodes may be a sensible one. To qualify the crop as a good biofumigant for the management of nematodes, the crop should be a poor host for the nematodes and lower the nematode population after incorporatingin soil (Viaene and Abawi, 1998). Although biofumigation often results in satisfactory levels of nematode control, the underlying mechanisms responsible for control are still largely unknown. In spite of this, biofumigation appears to be a very promising technique that could easily be integrated with other pest control measures and also it may offers alternative uses for some agricultural by-products. Biofumigation with Brassicaceae which stood as a promising alternative to conventional fumigation has its drawbacks too. Not all Brassicaceae plants are good biofumigants compare to several crops in the family with different host range.The fact that many crops in the same family are hosts to root-knot nematodes can result in an undesired population increase. Biofumigation is also an untargeted biocide. Non target free-living, beneficial nematodes (Henderson *et al*.2009; Ramirez *et al*. 2009), as well as other macro and micro soil organisms, may be harmed (Riga 2011; Zuluaga*et al*. 2015; Fouché*et al*. 2016). Growing a biofumigant crop can be costly and due to unfamiliarity and delayedresults, a potentially daunting proposition (Grabau*et al*.2017). Interpretation of the initial effectiveness and successive efficacy of biofumigation is still underway. Biofumigation with crops in the management of the root-knot nematodes aimed at assessing the financial feasibility of the biofumigation techniques used and the final profitability of the crops in terms of cost to benefit ratio. With careful planning there is potential for high success in managing nematodes.

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