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BREEDING FOR ACQUIRED DISEASE RESISTANCE IN OPEN POLLINATED YAM GENOTYPES THROUGH CYTOPLASM DEFENSE MECHANISM - A REVIEW

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ABSTRACT

Resistant varieties developed through plant breeding have made much contribution to Agriculture. This is because stability in crop production depends more on resistant varieties. Based on this, detailed review on the cytoplasm resistance and cytoplasm defense was carried out to enable Plant breeders develop yam genotypes with acquired disease resistance. Therefore yam plants that failed to inherit resistance genes could be made to acquire cytolasmic resistance mechanisms through field evaluation in hotspot agro ecologies. In cytoplasmic resistance, the plant plasmids acquired foreign genes to make such yam plant resistant to pathogens. Even if the pathogen has penetrated the preformed defense structures, the yam plants could respond by forming defense structures which involve the cytoplasm of the yam plant cells under attack to destroy the pathogen, a process known as cytoplasmic defense reaction. Protoplasm of related and unrelated yam plants could also be fused causing the regenerated yam plants to acquire resistance to major diseases. With these cytoplasmic defense mechanisms, yam plants could effectively thrive in pathogen prone environments. Developed disease resistant yam plants are not expensive to maintain and are environmentally friendly.

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INTRODUCTION

Yam species or rather a single of yam plant is attacked by hundreds of kinds or thousands of individuals of a pathogen yet those yam species or the single yam plant survive. This is because these yam species or single yam plant are resistant due to the fact that they adopted a number of mechanism which they have acquired such as cytoplasm resistance and cytoplasm defense. Chaudhary (2001) defined resistance to disease as the capability of plants to resist, withstand, lessen and overcome the attacks of parasites. Without resistance to parasites, plants would not be able to survive. Parasites are organisms which derive their food from plants on which they grow. As these parasites continue to grow on or inside the plant, the plant is no longer at ease. This is because the parasites has created disease condition in their host and so are called pathogens. Pathogens are one of the problems affecting yam cultivation in Nigeria.

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For instance, the annual yam losses caused by pathogens in Nigeria even in non epidemic years are estimated to be over 600 million US dollars. Nigeria is not an exception in pathogen attack, globally; pathogens have caused disasters that had created an unforgettable history. For instance, in 1845 potato blight disease in Ireland led to famine in which over one million people died and forced over one and half million to migrate to U.S.A as a result of famine (Awake, 1989). This is a clear example of the disastrous effect of pathogen influence. Nigeria is in the tropical zone of the world and is liable to the attack of more pests and diseases. As new crops are developed, Chaudhary (2001) observed that pathogens and their host plants originate and evolve together. However, the overzealous feeding habits of pathogens on their host plants have resulted into epidemic which eventually resulted into heavy crop losses and low yield. In the third century Chaudhary (2001) reported that the Greek Philosopher Theophrastas, was the first to record varietal differences for disease reaction. However, according to Chaudhary (2001) systematic resistance breeding started in 1905 when Biffen observed that resistance to yellow rust of wheat was governed by recessive genes. He reported a

3:1 ratio in F_2 for susceptibility to resistance. It was after then that breeding for disease resistance began. He highlighted that yield stability in crop production depends more on resistant varieties. Chaudhary (2001) substantiated this by giving many plus points for incorporating resistance to yam plants. However, resistance goes a long way in protecting yam plants for losses due to diseases and pests. It is the cheapest way for disease control and does not add to cost of production. Built-in-resistance is the only control measure against many diseases of yam such as root rots, soil borne diseases such as nematodes, anthracnose, and yam mosaic diseases and so on. Built-in-resistance is environmentally friendly unlike pesticides and fungicides which are hazardous to humans and insects. Disease resistance could be acquired by inheritance through hybridization and by incorporation through field evaluation in hotspot pathogen zones. Resistant yam plants do not pollute the soil, water or environment. Resistant varieties have made considerable contribution to plant breeding in terms of biological and economic yields. As a result of the benefits of disease resistant varieties, this review will discuss the "Breeding for Acquired Disease Resistance in Open Pollinated Yam Genotypes through Cytoplasm Resistance and Cytoplasm Defense."

Breeding for disease resistance: In breeding for disease resistance, resistant donors may be found in germplasm collections available with the breeder. Sometimes, donors are found in the wild yam species only. In using donors, the first choice is given to cultivated varieties, then wild species and last, to unrelated species because of the difficulty in making crosses and recovery of good segregants (Gasura *et al.,* 2008). If resistance is not available in the existing germplasm or are inadequate, mutation could be used to create suitable donors. Then these could be used as parents in incorporating resistance to their progenies through hybridization.

Incorporation of resistance through the cytoplasm: The methods used for developing resistant varieties are almost the same as for productive breeding that is breeding for high tuber yield. If resistance is governed by major genes, it involves a different handling of segregating material than when it is governed by recessive or polygenes. If governed by polygenes, selection in F_2 should be avoided because when a large number of genes are involved, the probability of getting a homozygous segregant is very low and Chaudhary (2001) reported that any selection pressure would destroy the other segregants which are heterozygous.

In order to incorporate disease resistant genes to the yam genotypes, artificial high disease pressure condition (epiphytotics.) are created. This outbreak of a plant disease that suddenly and rapidly affects many plants in a specific area are essentially designed in the field trial. Although, the procedure depends on the type of disease, nature of the crop and place of screening. (The laboratory procedures of screening are precise for inoculum load, control of light, humidity, temperature, wind and so on). However, field screening is usually done on hotspots. Hotspots are locations where disease occurs naturally every year with considerable intensity by growing in screening nurseries such diseases such as viruses. Sick plots are developed by growing susceptible variety year after year and even adding inoculum in a plot in the evaluation field. If the screening yam plants are grown in such a plot, only the resistant ones will survive. Some viral diseases which spread through insect vectors are inoculated by feeding insects on diseased plants. Such insects acquire virus and become viruleferous and are then released on the screening yam plants. Some varieties in coming in contact with the disease become resistant. The disease resistance acquired in this way is not sex-linked. That is the disease is not passed through the DNA in the nucleus during meiosis to be incorporated into the genome of the yam plant. It is acquired. How then do yam plants acquire disease resistant in their system instead of being inherited? Let us first examine the cytoplasm of the plant cell.

The cytoplasm: The cytoplasm is the material excluding the nucleus and could be said to be a complex of chemical compounds and structures within a plant or animal cell excluding the nucleus. The cytoplasm contains the cytosol, organelles, vesicles and cytoskeleton. Cytoplasm is mainly consists of water-base fluid called cytosol, within which all the other organelles and cellular solute materials are suspended. Cell organelles such as ribosome, rough and smooth endoplasmic reticulum, golgi apparatus, mitochondrion, lysosome vacuole, plant plastids, lipid droplets, and vacuoles are located in the cytoplasm. However, all the contents of the cells of prokaryotic organisms such as bacteria, which lack a cell nucleus, are contained within the cytoplasm. The DNA which carried the hereditary material is located in the nucleus. The cytoplasm is about 80% water and usually colourless. It is within the cytoplasm that most cellular activities occur, such as many metabolic pathways including glycolysis and processes such as cell division. The concentrated inner area is called the endoplasm and the outer layer is called the cell cortex or the ectoplasm. Movement of calcium ions in and out of the cytoplasm is a signaling activity for metabolic processes. In plants, movement of the cytoplasm around vacuoles is known as cytoplasmic streaming.

Bacteria (which most are disease causing agents) belong to unicellular organism called prokaryote that lack a membrane bound nucleus, mitochondria or any other membrane bound organelle. All the intracellular water-soluble components (proteins, DNA and metabolites) are located together in the cytoplasm enclosed by the cell membrane. The strands of deoxyribonucleic acid (DNA), the genetic material in all living cells are located in the cytoplasm. Most DNA in cells is packaged in structures called chromosomes. Some cells, including many bacteria cells, also contain small loops of DNA known as plasmids. Bacteria cell do not contain organelles in the same sense as that of eukaryotes. Instead, the chromosome and perhaps ribosomes are the only easily observable intracellular structures found in all bacteria cells. Bacterial reproduce without fusion of gametes because the bacterial DNA is not enclosed inside of a membrane-bound nucleus but instead resides inside the bacterial cytoplasm. This means that the transfer of cellular information through the processes of translation, transcription and DNA replication all occur within the same compartment and can interact with other cytoplasmic structures, notably ribosomes. Along with chromosomal DNA, most bacteria cells also contain small independent pieces of DNA called plasmids or other extra chromosomal DNA that often encode for traits that are advantageous but not essential to their bacterial host. These are circular structures in the cytoplasm that contain cellular DNA and play a role in horizontal gene transfer. The inheritance of genes in the cytoplasm is the inheritance of genes from the female parent that are not in the nucleus but in organelles such as mitochondria that are found in the cytoplasm. This type of inheritance is not controlled by Mendel's laws.

How cytoplasm acquires resistance to diseases: The plasmids in the cytoplasm of the cell can be easily gained or lost by a bacterium and can be transferred between bacteria as a form of horizontal gene transfer. So plasmids can be described as an extra chromosomal DNA in a bacterial cell or plant cell. A plasmid is a small DNA molecule within a cell that is physically separated from a chromosomal DNA in the nucleus and can replicate independently. They are most commonly found as small circular, double-stranded DNA molecules in bacteria; however, plasmids are sometimes present in the cells of eukaryotic organisms. In nature, plasmids often carry genes that may benefit the survival of the organism, for example plasmid can help the organism be antibiotic resistance. While the chromosomes are big and contain all the essential genetic information for living under normal conditions, plasmids usually are very small and contain only additional genes that may be useful to the organism under certain situations or particular condition. Plasmids may carry genes that provide resistance to naturally occurring antibiotics in a competitive environmental niche, or the proteins produced may act as toxins under similar circumstances, or allow the organism to utilize particular organic compounds that would be advantageous when nutrients are scarce (Marquis, 2009).

Bacteria can acquire antibiotic resistance genes from other bacteria in several ways. One of the ways is by undergoing a simple mating process called "conjugation." Through this way, the bacteria can transfer genetic material, including genes encoding resistance to antibiotics (found on plasmids and transposons) from one bacterium to another. Plasmid is a small chromosome, usually with ring-shaped molecule of deoxyribonucleic acid (DNA), which is the hereditary material in all living cells. Plasmids are present in almost all bacteria and may also be found in some yeast and other fungi, protozoa, and even some plants and animals. They are separate from chromosomes, the primary structures that contain DNA in cells. Plasmids are important tools used in genetic engineering the deliberate manipulation of an organism's genetic material and they are also key to scientists' understanding of how bacteria cause human disease. Plasmids carry hereditary information in the form of genes, the basic units of inheritance. Marquis (2009) observed that plasmids generally carry fewer genes than do chromosomes, and that the genes that they carry are useful, but they are not essential, to the survival of the cell. For example, some plasmids help bacteria make use of unusual food sources, such as camphor or petroleum and could assist in disease prevention.

Fertility plasmids carry genes that a bacterial cell must have in order to transfer DNA to another bacterium. Resistance plasmids enable bacteria to degrade or inactivate antibiotics used to halt bacterial growth, or to survive in the presence of heavy metals by converting the metals into less toxic forms. Other plasmids in the cell enable the bacteria to produce chemicals that are toxic to other organisms, including insects, humans, and other bacteria. Plasmids are important tools that are used in genetic engineering. Marquis (2009) noted that the structure of DNA is the same in all living cells, so DNA from almost any organism can be combined with plasmid DNA. Plasmids therefore serve as convenient vehicles for transferring genes from one organism to another.

Like in all cells, bacteria contain the genetic material DNA. But bacterial DNA is not contained within nucleus, as is DNA in plant and animal cells. Most bacteria have a single coil of DNA, although some bacteria have multiple pieces of DNA. Bacterial cells often have extra pieces of DNA. In bacterial cell, the plasmids in the cell may be gain or lose without the bacteria dying. Surrounding the DNA in the bacterial cell is cytoplasm, a watery fluid that is rich in proteins and other chemicals. A cell membrane inside the wall holds together the DNA and the constituents of the cytoplasm which are used mostly for reproduction and manufacture of proteins. Most bacteria have only one chromosome under normal circumstances, but may contain 1 to 100 or more copies of a given plasmid. Plasmids are located in the cytoplasm and replicate independently of cell division, and when a cell containing plasmids divides, the plasmids distribute randomly among the two resulting daughter cells. In this way, each daughter cell receives approximately—but not always exactly the same number of plasmids (Marquis 2009). Bacterial plasmids are also used to transfer foreign genes to plants which will make such plant like yam plants to be resistant to pathogens.

Plasmids are used in the genetic engineering of plants. It often involves a plasmid known as a tumor inducing, or Ti, plasmid found in *Agrobacterium tumefaciens*, the bacterium that causes crown gall disease in plants. When the *Agrobacterium tumefaciens* bacteria enter a plant such as yam plants through a wound, they transfer the Ti plasmid into nearby yam plant cells. The presence of the plasmid drastically changes the growth of the yam plant cells, resulting in the formation of a large tumor on the yam plant. This natural process is used by scientists to manipulate the bacteria *Agrobacterium* by removing the Ti plasmids from the *Agrobacterium tumefaciens* cells and to replace the plasmids' tumor-causing genes with genes that code for desirable characteristics. These recombinant plasmids are then introduced into plant cells to produce, crop plants that are resistant to certain diseases, insect pests, or herbicides. This technique may also be used to improve the nutritional value of some food plants. Therefore the recombinant plasmid could be introduced into the cells of yam plant to produce genotypes resistant to virus diseases.

Genetic Exchange: Bacterial cells often can survive by exchanging DNA with other organisms and acquiring new capacities, such as resistance to an antibiotic intended to kill them. The simplest method of DNA exchange is genetic transformation, a process by which bacterial cells take up foreign DNA from the environment and incorporate it into their own DNA. The DNA in the environment may come from dead cells. The more the DNA resembles the cell own DNA, the more readily it is incorporated. Another means of genetic exchange is through incorporation of the DNA into a virus. When the virus infects a bacterial cell, it picks up part of the bacterial DNA. If the virus infects another cell, it carries with it DNA from the first organism. This method of DNA exchange is called transduction. Transformation and transduction generally transfer only small amounts of DNA. Marquis (2009) reported that many bacteria are also capable of transferring large amounts of DNA or even the entire genome (set of genes), through physical contact. The donor cell generally makes a copy of the DNA during the transfer process so that it is not killed. This method of exchange is called conjugation. DNA exchange enables bacteria that have developed antibiotic resistant genes to rapidly spread their resistance to other bacteria. Most of these processes takes place within the cytoplasm of the cell and between the cytoplasm of cells. Therefore bacteria causing pathogens could transfer large amounts of DNA through physical contact of the cells of yam plants thereby conferring resistance to certain major diseases attacking the crop in the field. That is why while breeding for disease resistance in yam genotypes, the diseased plants or host diseased plants are included in the evaluation plots to enable the new yam genotype acquire/develop resistance to the target pathogen(s).

Viral transformation (**transduction**): This is a method of packaging the desired genetic material into a suitable plant virus and allows this modified virus to infect the plant. The genetic material which is the DNA can recombine with the chromosomes in the cytoplasm to produce transformant cells. However, genomes of most plant viruses consist of single stranded RNA which replicates in the cytoplasm of infected cell. For such genomes, this method is a form of transfection and not a real transformation. Transfection is the transfer of viral material or the infection of a cell with viral DNA leading to the production of the virus in the cell. Since the inserted genes never reach the nucleus of the cell and do not integrate into the host genome, the progeny of the infected plants is virus-free and also free of the inserted gene. Yam plants which acquire resistance by being exposed to viral infection this way can remain viral free or resistant for a very long time (Balmori, *et al*. 2002).

Acquired resistance is said to occur when a particular microorganism obtains the ability to resist the activity of a particular antimicrobial agent to which it was previously susceptible. Antibiotic resistant bacteria are bacteria that are not controlled or killed by antibiotics. They are able to survive and even multiply in the presence of an antibiotic. Most infection-causing bacteria can become resistant to at least some antibiotics. Scientists can force bacteria to keep them. Virtually all plasmids that are used to deliver DNA contain genes for antibiotic resistance. Once bacteria have been treated with a plasmid, scientists grow them in the presence of antibiotic. Only those cells that contain the plasmid will survive, grow and reproduce.

Cytoplasmic defense reaction

Despite the preformed superficial or internal defense structures of host plants, Agrios (2005) observed that most pathogens manage to penetrate their hosts through wounds and natural openings and to produce various degrees of infection. Even after the pathogen has penetrated the preformed defense structures, yam plants usually respond by forming one or more types of structures that are more or less successful in defending the plant from further pathogen invasion. Some of the defense structures formed by some plant genotypes involve the cytoplasm of the cells under attack, and the process is called cytoplasmic defense reaction. Chaudhary (2001) reported that hypersensitive reactions is a potential defense reaction which resulted as an increased sensitivity of hosts cells in the vicinity of infection site and is expressed as the necrotic area. According to Chaudhary (2001) and Agrios (2005) the necrotic tissue separates the parasite from the living host and thereby stops further growth of the pathogen. Chaudhary (2001) however, described hypersensitivity as "all morphological and histological" changes that when produced by an infectious agent elicit the premature dying off (necrosis) of the infected tissue as well as inactivation and localization of the infectious agent. He gave an example of phytophthora infestans resistance of potato as the hypersensitive type. This type of resistance is governed by cytoplasm factors. However, the duration for which a yam variety remains resistant depends on the yam crop, the pathogen nature of resistance and the location where yam plant is cultivated. Resistance to pathogen also involves crop cultivation method, crop rotation and land rotation, length of vegetation or fallow system, type of pathogen, alternative hosts and several other factors. A yam variety remains resistant only as long as there is no pathogen that attacks it.

Some of the developed yam plant genotypes defend themselves against pathogens through cytoplasm defense. This can take place through the hypersensitive response (Cao, and Dong, 1998). The hypersensitive response is considered as a biochemical defense mechanism that took place in the cytoplasm of the cell of the plant. Take for instance, as soon as the pathogen attack the yam plant genotype and establishes contact with the cell of the host plant, the nucleus of the attacked cell moves toward the invading pathogen and soon disintegrates. At the same time, brown, resin-like granules form in the cytoplasm, first around the point of penetration of the pathogen and then throughout the cytoplasm (Agrios, 2005). As the browning discoloration of the yam plant cell cytoplasm continues, death sets in, the invading hypha begins to degenerate and die. In most cases the hypha does not grow out of such cells, and further invasion is stopped.

In bacterial infections of leaves of the hybrid yam genotype, the hypersensitive response results in the destruction of all cellular membranes of cells in contact with the bacteria, which is followed by desiccation and necrosis of the leaf tissues invaded by the bacteria. Apparently, the necrotic tissue isolates the parasite from the living substance on which it depends for its nutrition thereby, resulting in its starvation and death. This signifies the concentration of numerous biochemical cell responses and antimicrobial substances that neutralize the pathogen within the cytoplasm of the cell. This leads to cellular degradation and inactivation of the pathogen. The faster the host cell dies after invasion, the more resistant to infection the yam plant seems to be. The compounds and pathways developed during the hypersensitive response latter serves as the springboard for localized and systemic acquired resistance for the yam plant.

Agrios (2005) stated that in cases of slowly growing, weak pathogenic fungi that induce chronic diseases or nearly symbiotic conditions, the cytoplasm surrounds the clump of hyphae, and the nucleus is stretched to the point where it breaks in two. In some cells, the cytoplasmic reaction is overcome and the protoplast disappears while fungal growth increases. In some of the invaded cells, the cytoplasm and nucleus enlarge. The cytoplasm becomes granular and dense, and various particles or structures appear in it. Finally, the mycelium of the pathogen disintegrates and the invasion stops leading to the survival of the yam plant.

Necrotic Defense Reaction: This also work like defense through hypersensitivity. In many host-pathogen combinations, the pathogen may penetrate the cell wall, but as soon as it establishes contact with the protoplast of the cell , the nucleus moves toward the invading pathogen and soon disintegrates, and brown, resin like granules form in the cytoplasm , first around the pathogen and then throughout the cytoplasm. As the browning discoloration of the cytoplasm of the plant cell continues and death sets in, the invading hypha begins to degenerate. In most cases the hypha does not grow out of such cells and further invasion is stopped. In bacterial infections of leaves of the yam plant, the hypersensitive reaction results in destruction of all cellular membranes of cells in contact with the bacteria, and that is followed by desiccation and necrosis of the leaf tissues invaded by the bacteria. According to Bauer *et al*. (1995), necrotic or hypersensitive type of defense is quite common, particularly in diseases caused by obligate fungal parasites and by viruses and nematodes. Apparently, the necrotic tissue isolates the obligate parasite from the living substance on which it depends absolutely for its nutrition and, therefore, results in its starvation and death. The faster the host cell dies after invasion, the more resistant to infection the yam plant seems to be. The isolated and death of the yam plant tissues that fell out of the leaves form spots on the leaves.

Disease Resistance by Protoplast Fusion

Agrios (2005) reported that protoplasts from closely related and even from unrelated plants, under proper conditions, can be made to fuse. The fusion produces hybrid cells containing the nuclei (chromosomes) and the cytoplasm of both protoplasts or it might result in cybrid cells containing the nucleus of one cell and the cytoplasm of the other cell. Although, hybrids of unrelated cells normally abort or may produce calluses, but they do not regenerate plants. In combinations of more or less related cells, many or most of the chromosomes of one of the cells are eliminated during cell division; one or a few chromosomes of that cell survive and may be incorporated in the genome of the other cell. In this way, plants with more chromosomes and new characteristics can be regenerated from the products of protoplast fusion. According to Agrios (2005) protoplast fusion is particularly useful between protoplasts of different, highly resistant haploid lines of the same variety or species. Protoplast fusion of such lines results in diploid plants that combine the resistance genes of two highly disease resistant haploid lines.

Genetic Transformation of Plant Cells for Disease Resistance

Broglie et al. (1991) reported that DNA material for disease resistant can be introduced into the protoplasts by several methods. Such methods include direct DNA uptake, microinjection of DNA, liposome (lipid vesicle)-mediated delivery of DNA, delivery by means of centromere plasmids (minichromosomes), use of plant viral vectors, and, through the bombardment of cells with tiny spheres carrying DNA and by use of A. tumefaciens. In all of these methods, small or large pieces of DNA are introduced into plant cells or protoplasts, and the DNA may be integrated in the plant chromosomal DNA. When the introduced DNA carries appropriate regulatory genes recognized by the plant cell or is integrated near appropriate regulatory genes along plant chromosomes, the DNA is “expressed,” or transcribed into mRNA, which is then translated into protein (Agrios, 2005) which react against certain diseases. Also Agrios (2005) noted that only microprojectile bombardment and the Agrobacterium system have been used successfully to introduce into plants specific new genes that were then expressed by the plant. This was accomplished by isolating several genes of interest from plants or pathogens and splicing them into appropriate plasmids. These were used to coat the surface of tiny spheres, which were bombarded into plant cells or were introduced into a disarmed Ti plasmid of Agrobacterium. The bacteria were then allowed to infect appropriate other plants. On infection, about one-tenth of the DNA of the plasmid, containing the new gene, is transferred to the plant cell and is incorporated into the plant genome. There, the new gene replicates during plant cell division and is expressed along with the other plant genes.

Different kinds of plants can be genetically transformed for disease resistance (Boucher *et al*., 1992). When viral, bacterial, fungal, or plant genes are introduced into plants through genetic engineering techniques, it provide various degrees of resistance (pathogen-derived resistance) in the plant to the pathogen from which the gene or DNA fragment was obtained and also to other pathogens. Genetic engineering of plants for disease resistance is now used in practice with several crops. Plants that are engineered for resistance to viruses, such as cucurbits engineered for resistance to *cucumber mosaic*, *watermelon mosaic*, and *zucchini yellow mosaic viruses*; papaya engineered for resistance to *papaya ringspot virus*; potato engineered for resistance to *potato leaf roll* and *potato Y viruses*; and wheat engineered for resistance to *wheat streak mosaic virus* are some examples that cells of yam plants could be engineered to be resistant to diseases using biotechnique tools.

Plant protection using natural defence systems of plants

Plants' using their natural defense systems at threatening times during disease development suggests the prospect of plant protection in agriculture. Resistant yam cultivars are developed by plant breeding after selection of recognizable genes for countering harmful strains of pathogens. These present methods of largely planting of resistant yam cultivars are better than the application of control agents such as fungicides developed in the chemical industries (Chaudhary, 2001). Such chemicals too have their health hazards. Agrios (2005) felt concerned about depleting genetic resources, evolution of new strains of pathogens and use of fungicides. This concern encourages exploration for other easy and cheaper methods. This method include the development of yam plants using their defensive methods in disease control which is cheaper and less health hazardous. There is a worldwide mission to use 'integrated pest and disease management' in plant protection. This means the selection and use of as many procedures as possible for minimizing loss caused by pests and diseases in a balanced way in yam cultivation. A desirable component of such management would be the manipulation of the active defense systems in yam plants such as using the cytoplasmic resistance, protoplasmic fusion and cytoplasmic defense. However, the plant breeding approach in the ability and prospects of activating these defense systems in yam plants with effective control of disease in mind will be a welcome development. It focuses mainly on the genetic development of systemic disease resistance in yam plants. This means the heightening of disease resistance throughout the histology of yam plant by cross breeding.

Usefulness of cultivating resistant yam varieties

Agrios (2005) enumerated the usefulness of plants developing and or acquiring its own resistance. According to Agrios (2005), the use of resistant varieties is the least expensive, easiest, safest, and one of the most effective means of controlling plant diseases in crops. The cultivation of resistant yam varieties not only eliminates losses from diseases, but also eliminates expenses for sprays and other methods of disease control and avoids the addition of toxic chemicals to the environment that would otherwise be used to control plant diseases. Gaudet, *et al.* (2000) noted that many diseases, such as those caused by vascular pathogens and viruses, that often cannot be controlled adequately by other means, and for others, such as cereal rusts, powdery mildews, and root rots, that are economically impractical to control in other ways, the use of resistant varieties provides a means of producing acceptable yields without any pesticides. Varieties of yam crops resistant to some of the major important or most difficult to control diseases are made available to growers by International and national research stations and by commercial seed companies. More than 65% of the total agricultural /arable land under cultivation in the country - Nigeria is planted with varieties that are resistant to one or more diseases. It could be said that Nigerian farmers have gained the most from the use of varieties resistant to fungi causing rusts, smuts, powdery mildews, and vascular wilts attacking cassava, rice, legumes and tree crops like cocoa but several other kinds of fungal diseases and many diseases caused by viruses, bacteria, and nematodes are also controlled through resistant varieties.

Resistant varieties cannot continue to be resistant without assistance. There are however, several techniques used to increase the useful “life span” of a resistant variety. During the plant development, the varieties are first tested for resistance against as many pathogens and as many races of the pathogens as are available by growing and evaluating the varieties for disease resistance in many locations across the country. The sweet potato varieties UMUSPO/1, UMUSPW/2 and UMUSPO/3 developed and released in 2012 and 2013 by National Root Crops Research Institute, Umudike, Nigeria are evaluated this way before the official release (Nwankwo, *et al,* 2014*)*. So national breeding programs also carry out adaptation breeding to incorporate resistance to local pathogens. The variety or varieties acquired resistances to major pathogens attacking the crop plant before they are released as resistant varieties. After the release, measures are taken to prolong its resistance. Management strategy such as sanitation, seed treatment, or fungicide application that reduces the exposure of the variety to large pathogen populations (inoculum pressure) is likely to increase its useful life span. For slowly dispersing pathogens such as soil borne pathogens, rotation of varieties with different sources of resistance reduces pathogen populations compatible with each variety so that each variety can last longer (Agrios, 2005).

However, yam plants that acquired or inherited resistance may be lost after sometime due to environmental changes that affect resistance. This is because resistance genes function under a set of environmental factors. Loebenstein *et al.,* (2009) agreed with Agrios (2005) that resistance genes may be lost due to mutation and segregation due to hybridization. This may lead to erosion resistance. Resistance may also be lost when the pathogen may create new races or biotypes. Once new yam varieties are released, the pathogens change in response to develop new virulent races. This has kept plant breeders busy breeding new crop varieties resistant to pathogens to replace current ones for at least every two to seven years.

Conclusion

Healthy yam plants grow in an atmosphere crowded with fungal spores, bacterial cells, and viruses; in soil, healthy roots predominate despite the high numbers of fungal spores, bacterial cells, and nematodes that thrive in the rhizosphere (soil immediately around the roots of the plant). In the face of this onslaught of potential pathogens, yam plants defend themselves with an arsenal of weapons, and, as a result, most yam plants are resistant to most pathogens. Most yam plants have developed defense strategies that successful pathogens must overcome. Although some yam plants defend themselves against potential pathogens in different ways, knowledge and exploitation of host yam defenses can lead to new pathogen control strategies. Successful host yam defenses disrupt the disease cycle by its natural resistance cell cytoplasm and yield highly. Therefore yam plants that failed to inherit resistance genes could be made to acquire cytolasmic resistance and cytoplasmic defense mechanisms through field evaluation in hotspot agro - ecologies or through protoplasmic fusion through use of biotecthnological tools.

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