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Genetic Consequence of Polyploidy in Plant Breeding

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Abstract

Polyploidy plays an important evolutionary role in natural populations. This role can be attributed to a number of consequences of polyploidization that promote phenotypic and/or fitness alterations, such as mutation buffering, increased allelic diversity and heterozygosity, dosage effects, and sub-or neofunctionalization of duplicated genes. Considering the significant challenges, humanity is facing in relation to food supply and climate change, understanding the role that polyploidy plays in enhancing plant tolerance to various types of stress and in expanding the range of conditions for plant establishment may lead to better breeding and crop-improvement strategies. Polyploidy is defined as having more than two sets of chromosomes, and it has long been recognized as a major driver of plant evolution and speciation. A creature with more than two haploid sets of chromosomes is known as a polyploid. Polyploidization has considerably aided plant breeding and agriculture improvement. Polyploidy is likely one of the most important mechanisms of plant adaptation, having been researched extensively over the previous century. It occurs frequently in both plants and mammals. One evolutionary mechanism aids speciation, diversification, and adaptation to changing environmental conditions. Polyploidy is currently an interesting research topic for understanding agricultural plant evolution and utilizing its diversity in crop breeding. The most common use of polyploidy is to overcome or remove sterility in hybrids created via interspecific or inter-generic hybridization or remote cross. Significant economic and societal benefits have resulted from the invention and application of polyploidy breeding. Polyploidy is induced in numerous agricultural plants using diverse ways. The purpose of this paper is to assess polyploidy, classification, and its application in plant breeding.

Keywords: Abiotic stress; Plant breeding; Biotic stress; Polyploidy; Genome duplication

Introduction

Climate change is challenging the agriculture in very difficult manner (Thornton et al., 2018). It will result in higher temperatures, drought, and increased soil salinity (Korres et al., 2016). As a major force for plant evolution (Yin et al., 2010), polyploidy promotes better adaptation traits in crops, since polyploidy plants are thought to have been selected during evolution because of their phenotypic and genomic plasticity (Leitch and Leitch, 2008). Much larger proportions of polyploidy plants have been found in the Arctic (Brochmann et al., 2004) and at mountainous elevations (Schinkel et al., 2016), suggesting that these genotypes are better adapted to severe cold climatic constraints. Most plant lineages have undergone whole genome duplication events in their past (Ruprecht et al., 2017), with some lineages experiencing repeated doubling events [1].

Polyploidy is one of the main factors driving evolution in higher plants (Hollister et al., 2012), conferring genotypic plasticity by increasing the number of copies of the genome (autopolyploidy) or adding different genomes (allopolyploidy), thus increasing their potential for adaptation (Leitch and Leitch, 2008) and promoting their selection (Feldman and Levy, 2012) [2]. It has been proposed that polyploidy favors adaptive evolution to changing environmental conditions (Ramsey, 2011) through differential expression of duplicate genes (Tan et al., 2015). In agriculture, the genomic modifications that take place during polyploidization confer many interesting advantages over the diploid (2x). The most important for crop production are dwarfing effect on trees, increase in organ biomass (leaves, fruit, seeds, roots, etc.), alteration of flowering time and intensification of color (leaves and fruit) [3].

Provokingly, the adaptive potential derived from the plasticity shown by natural polyploidy in the face of the stress imposed by environmental changes can also be regarded as a two-way phenomenon, in which the environmental stress can also facilitate the occurrence of whole genomic duplication events. The production of unreduced gametes is the main mechanism that gives rise to polyploidy in nature (Soltis et al., 2009). Polyploidy can be classified, as autopolyploid or allopolyploids, and these can be either natural or artificial (chemically induced) (Hegarty et al., 2013) [4]. Autopolyploid result from the doubling of one chromosome set within one species; whereas in allopolyploids, chromosome sets of different species can combine through hybridization events and, subsequently, increase their number through duplication events. During polyploidization, structural and functional changes in genomes such as chromosomal rearrangements and miRNAome alterations can have a huge impact on gene expression.

Among the many genomic responses to merging and doubling, changes in the activity of transposable elements seem to play a key role in the adaptation to different stresses by modification of the expression of stress-related genes (Quadrana et al., 2019) [5]. Environmental changes or stress can result in the proliferation of highly mutagenic transposable elements due to a transient relief of gene silencing (Edger et al., 2017), and also to the presence of specific activator sequences in transposable elements promoters (Galindo-González et al., 2017). Particularly, genomic transposable element content frequently increases after polyploidization events, usually affecting specific transposable element families, which may be more susceptible to

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activation (Yaakov and Kashkush, 2012). In the face of rapid climatic and other environmental changes at the global scale, understanding the impact of polyploidization in plant evolution and ecological interactions is of an uttermost relevance, as this knowledge might rapidly become an important tool for the breeding of economically important crops, helping us to pave the way for harnessing more efficient uses of artificial polyploidization to obtain genotypes with increased tolerance to diverse biotic and abiotic stresses [6].

Polyploidy, defined as the coexistence of three or more complete sets of chromosomes in an organism's cells, is considered as a pivotal moving force in the evolutionary history of vascular plants and has played a major role in the domestication of several crops. Polyploidy refers to the presence of more than two complete sets of chromosomes per cell nucleus, which has been considered a ubiquitous phenomenon in plant evolution and diversification (Soltis et al., 2009) [7]. It is thought to contribute to adaptation to climate and edaphic changes, by increasing effective population size and decreasing inbreeding depression in the short term. Polyploidy has played an important role in the evolution of higher plants. Approximately 50-70% of angiosperms, which include many crop plants, have undergone polyploidy during their evolutionary process (Chen et al., 2007). Flowering plants form polyploidy at a significantly high frequency of 1 in every 100,000 plants (Comai, 2005) [8].

The basic complete set of chromosomes is designated by "x" while the total number of chromosomes in a somatic cell is designated "2n". The total number of chromosomes in a somatic cell is twice the haploid number (n) in the gametes (Acquaah, 2009). In diploids, x = n, but at higher levels of polyploidy, this is not the case (Birchler, 2012). Two major pathways are known to lead to polyploidy in plants: somatic doubling and formation of unreduced reproductive cells. However, Polyploidy are of two basic types. Those that arise from a single species are called autopolyploid, whereas those that combine the genomes of two or more related species are called allopolyploids (Hollister et.al. 2012). Potentially has an important ecological and evolutionary consequence for the fate of introduced plant species [9].

Crop enhancement have benefited greatly from polyploidization (Corneillie et al., 2019). Plant breeding plays a significant part in the improvement of plant traits. This is necessary for the successful and cost-effective development of the new variety (Nadeem et al., 2018). Plant breeding is a technique for extracting desirable traits from a variety of sources. For crop enhancement, many sorts of breeding procedures have been created. Plant breeders can assist farmers in increasing food production by developing new cultivars that are more pleased to their farming methods, but these cultivars must be able to provide the essential plant inputs for the requisite crop yields (Bradshaw, 2017) [10].

Polyploidy is a fascinating phenomenon in plants that has served as a crucial evolutionary and speciation pathway (Van de Peer et al., 2021). Polyploid organisms have more than two copies of each chromosome, which is a situation that is rarely tolerated in animals but is common in plants (Bourke et al., 2018). Intraspecific genome duplication (autopolyploidy) or hybridizing divergent genomes and chromosomal doubling (allopolyploidy) can produce an additional set of chromosomes (Zhang et al., 2019) [11]. Polyploidy occurs when an organism's cells have more than one pair of (homologous) chromosomes. It is a heritable phenomenon in which a cell nucleus has more than two complete sets of chromosomes, and it is quite frequent in plants (Comai, 2005). Most polyploidy contain an even number of chromosomal sets, with four being the most prevalent (tetraploidy), which has been thought to be a one of a kind phenomenon in plant evolution and diversification (Madani et al., 2021). In general, all organisms have a consistent chromosomal number, which is determined by the species (Ohbayashi et al., 2019). The objective of this review was to understand the application of polyploidy in crop improvements [12].

Polyploidy

Polyploidization results in multiplication of the genome and an increase in gene content that frequently leads to morphological and physiological differences between polyploids and their diploid progenitors. Polyploidy is typically divided into at least two categories that are determined by the type of chromosome pairing in meiosis I and the distribution of chromosomes during this process. Indeed, the type of chromosome pairing that occurs in meiosis affects the genetic properties of the species so such classifications have value (Birchler, 2012). Polyploidy can occur in many other combinations such as triploids with three sets of chromosomes (3x), four sets are tetraploids (4x), six sets are hexaploids (6x) (Stebbins, 1947) [13].

Consequence of polyploidy

The most widespread consequence of polyploidy in plants is the increase in cell size, caused by the larger number of gene copies and referred to as the "gigas" effect Consequently, polyploid individuals may exhibit larger organs compared to their diploid counterparts, such as roots, leaves, tubercles, fruits, flowers and seeds. Polyploid plants also have lower growth rates, and tend to flower later or over a longer period of time than related diploids, which is a desirable feature for ornamental breeding (Levin, 2002). The reduction in fertility is another common consequence of autopolyploidy and may result from issues concerning the multivalent formation and meiotic irregularities (Stebbins, 1947). However, an immediate consequence of polyploidy is the change in gametic and filial frequencies [14].

Some of the most important consequences of polyploidy for plant breeding are the increment in plant buffering of deleterious mutations, increased heterozygosity and heterosis (hybrid vigor). Regarding such features as tools, cultivars have been generated with higher yield levels, improving the product quality and increasing the tolerance to both biotic and a biotic stresses. The formation of unreduced gametes is under genetic control and heritable, but may also be affected by environmental stress stimuli (Parisod et al., 2010), such as habitat disturbance, nutritional stress, physical stress and climate fluctuations (Bretagnolle and Thompson, 1995). Mutations and heterosis, or hybrid polyploidy has been broadly classified into two types, one involving interspecific hybridization, known as allopolyploidy, and another in the absence of interspecific hybridization, known as autopolyploidy [15].

Consequences of polyploidy in plants may include a much higher rate of gene loss, and Genetics more rapid apparent decay of synteny than in animals (Bowers et al., 2003).The revelation that a large number of plant species have a polyploid genome, including several important crops, has attracted the attention of plant breeders for the application of artificial polyploidy as a tool for crop improvement. However, therefore, autopolyploidy induction in breeding programs is usually restricted to crops cultivated for their vegetative organs and those with vegetative propagation, due to the low rates of viable seed production (Paterson, 2005). The breeding for seedless fruits is an exception, since in this case the low number of seeds is a desirable characteristic, such as in the triploid watermelon. In addition, autopolyploidy may positively affect the tolerance to some stresses, such as nutrient deficiency, drought, water deficit, temperature, pests and pathogens [16].

Classification of polyploids

Basically, polyploids can be formed by intra-species genome duplication or following hybridization. Polyploidy may be classified based on their chromosomal composition into either euploids or aneuploids.

Euploidy

Euploids are polyploids with multiples of the complete set of chromosomes specific to a species. Euploids constitute the majority of polyploids [17]. The variation may be multiples of the complete set of chromosomes (George, 2015). Depending on the composition of the genome, euploids can be further classified into either autopolyploids or allopolyploids. Tetraploidy is the most common class of euploids (Comai, 2005). Polyploids may be classified based on their chromosomal composition into either euploids or aneuploids. Euploids constitute the majority of polyploids. Euploids are polyploids with multiples of the complete set of chromosomes specific to a species. Depending on the composition of the genome, euploids can be further classified in either autopolyploid or allopolyploids. Tetraploidy is the most common class of euploids (Comai, 2005) (Table 1) [18].

Aneuploidy

Aneuploidy is defined as the deviation from a multiple of the haploid number of chromosomes in a cell (Mamas, 2012). The presence of multiple homologous chromosomes often results in spurious pairing between multiple chromosomes, unpaired chromosomes, and gametes with unbalanced chromosome numbers (aneuploidy. Aneuploidy refers to chromosome numbers that are not exact multiples of n (Guo et al., 1996). The variation may be incomplete set of chromosomes (aneuploidy) [19].

Infertility can arise because the new tetraploid form has more than two sets of homologous chromosomes and during meiosis, there can be trouble in how the cell pairs the chromosomes, resulting in unpaired chromosomes and unbalanced sets of chromosomes (aneuploids). However, when one or more chromosomes are lost or gained, there are deletions and duplications of many genes, resulting in an unbalanced, usually lethal or sub vital constitution referred to as aneuploidy. With no mechanism of dividing univalent equally among daughter cells during anaphase I, some cells inherit more genetic material than others (Ramsey and Schemske, 1998). Similarly, multivalent such as homologous chromosomes may fail to separate during meiosis leading to unequal migration of chromosomes to opposite poles. This mechanism is called non-disjunction (Acquaah, 2009). These meiotic aberrances result in plants with reduced vigor (Table 2) [20].

Table 1: List of major crop and their ploidy.

Common Name	Ploidy	Name	Propagation
Maize	2x=20	Diploid	Out Crossing
Sorghum	2x=20	Diploid	Selfing
Wheat	6x=46	Hexapod	Out Crossing
Rice	2x=24	Diploid	Selfing
Potatoes	4x=48	Tetraploid	Outcrossing, Vegetative
Soybean	2x=40	Diploid	Selfing
Barley	2x=14	Diploid	Selfing
Tomato	2x=24	Diploid	Selfing
Banana	3x=33	Triploid	Vegetative
Watermelon	2x=22	Diploid	Out Crossing
Sugarcane	8x=80	Octoploid	Outcrossing,Vegetative
Sugar Beat	2x=18	Diploid	Out Crossing
Cassava	2x=36	Diploid	Outcrossing,Vegetative

Table 2: Classification of aneuploidy.

Terms	Chromosome number
Monosomy	2n-1
Nullisomy	2n-2
Trisomy	2n+2
Tetrasomy	2n+2
Pentasomy	2n+3

Autopolyploidy

Autopolyploidy is a process whereby the chromosome set is multiplied and it is a common phenomenon in angiosperms. Autopolyploidy is thought to be an important evolutionary force that has led to the formation of new plant species. Natural autoploids include tetraploid crops such as alfafa, peanut, potato and coffee and triploid bananas [21]. Spontaneous chromosome doubling in ornamentals and forage grasses has led to increased vigor. For instance, ornamentals such as tulip and hyacinth, and forage grasses such as ryegrasses have yielded superior varieties following spontaneous chromosome doubling (Acquaah, 2009). Due to the observed advantages in nature, breeders have used the process of chromosome doubling in vitro through induced polyploidy to produce superior crops. For example, induced autotetraploids in the watermelon crop are used for the production of seedless triploid hybrids fruits (Wehner, 2008). Such polyploids are induced through the treatment of diploids with mitotic inhibitors such as dinitroaniles and colchicine (Table 3) [22].

Allopolyploids

Allopolyploids include important crops such as wheat, cotton, and canola, and all have improved agricultural traits relative to their diploid progenitors. They are a combination of genomes from different species (they may also be duplicates of different species) (George A, 2015). They result from hybridization of two or more genomes followed by

Table 3: Auto- And Allopolyploidy of Cultured Plants.

Auto- and Allopolyploidy of Cultured Plants		
Species	**Basic Number (X)**	**Number of Chromosomes (2n)**
AUTOPOLYPLOIDY		
Potato *(Solanum tuberosum)*	12	48
Coffee *(Coffea arabica)*	11	22, 44, 66, 88
Banana *(Musa sapientum)*	11	22, 33
Alfalfa *(Medicago sativa)*	8	32
Peanut *(Arachis hypogaea)*	10	40
Sweet Potato *(Ipomoea batata)*	15	90
ALLOPOLYPLOIDY		
Tobacco *(Nicotiana tabacum)*	12	48
Cotton *(Gossypium hirsutum)*	13	52
Wheat *(Triticum aestivum)*	7	42
Oats *(Avena sativa)*	7	42
Sugar-Cane *(Saccharum officinarum)*	10	80
Plum *(Prunus domesticus)*	8	16, 24, 32, 48
Strawberry *(Fragaria grandiflora)*	7	56
Apple *(Malus sylvestris)*	17	34, 51
Pear *(Pyrus communis)*	17	34, 51

chromosome doubling or by the fusion of unreduced gametes between species. Thus, allopolyploids typically have two or more distinct sub genomes at the time of their origin, are fixed heterozygotes at many loci and typically have chromosomes that do not form multivalent at meiosis. Allopolyploidy has played an important role in evolution [23].

Allopolyploidy occurs in various genera of plants and has enjoyed considerable success in natural populations. Two sub-classes: true and segmental allopolyploids. The formation of true allopolyploids involves hybridization between distantly related species. In this case, the divergent chromosome complements do not pair with each other, resulting in the formation of bivalents during meiosis and in a disomic inheritance pattern. On the other hand, segmental allopolyploids originate from hybridization between closely related specie with partially differentiated genomes [24].

Therefore, segmental allopolyploids may undergo univalent, bivalent or multivalent pairing during meiosis, being considered intermediate types between true allopolyploidy. It is expected that one third of the angiosperms are polyploids and a huge number of them are allopolyploids. Allopolyploids have been more successful as crop species than autopolyploids. Important natural alloploid crops include strawberry, wheat, oat, upland cotton, oilseed rape, blueberry and mustard (Chen, 2010) This process is key in the process of speciation for angiosperms and ferns (Chen, 2010) and occurs often in nature [25].

Common applications of polyploidy in plant breeding

Episodes of polyploidy have clearly played a major role in the evolution and speciation of plants. Polyploidization events often seem to be associated with increases in vigor and adaptation of the newly formed polyploid to novel conditions. According to Van de Peer et al. (2009), the competitive advantage of polyploids over their diploid progenitors is mostly related to transgressive segregation, i.e., formation of extreme phenotypes and increased vigor.

Mutation breeding: High frequencies of chromosome mutations are desirable in modern breeding techniques, such as tilling, as they provide new sources of variation. The multi-allelic nature of loci in polyploids has many advantages that are useful in breeding. The masking of deleterious alleles, that may arise from induced mutation, by their dominant forms cushions polyploids from lethal conditions often associated with inbred diploid crops. This concept has been instrumental in the evolution of polyploids during bottlenecks where there is enforced inbreeding (Comai, 2005) [26].

Seedless fruits: the seedless trait of triploids has been desirable especially in fruits. Commercial use of triploid fruits can be found in crops such as watermelons and are produced artificially by first developing tetraploids which are then crossed with diploid watermelon. In order to set fruit, the triploid watermelon is crossed with a desirable diploid pollen donor (Figure 1).

Bridge crossing: Bridge crossing is a technique of indirectly crossing two parents that differ in ploidy levels through a transitional or intermediate cross. This method has been used to breed for superior tall fescue grass from Italian ryegrass (2n=2x=14) and tall fescue (2n=6x=42) by using meadow grass (Acquaah, 2009) [27].

Ornamental and forage breeding

One of the immediate and obvious consequences of polyploidy in plants is an increase in cell size, which in turn leads to enlarged plant organs, a phenomenon termed gigas effect (Acquaah, 2009). For example, the volume of tetraploid cells usually is about twice that of their diploid progenitors (Acquaah, 2007). The increase in cell volume however is mainly attributed to increased water and not biomass. Therefore, its application is limited for breeding agronomically important crops such as cereals. Although chromosome doubling may result in significantly larger seeds and increased seed-protein content in cereal crops, this advantage is offset by, low seed set (Dhawan and Lavania, 1996). In contrast, the gigas effect has been explored in tree,

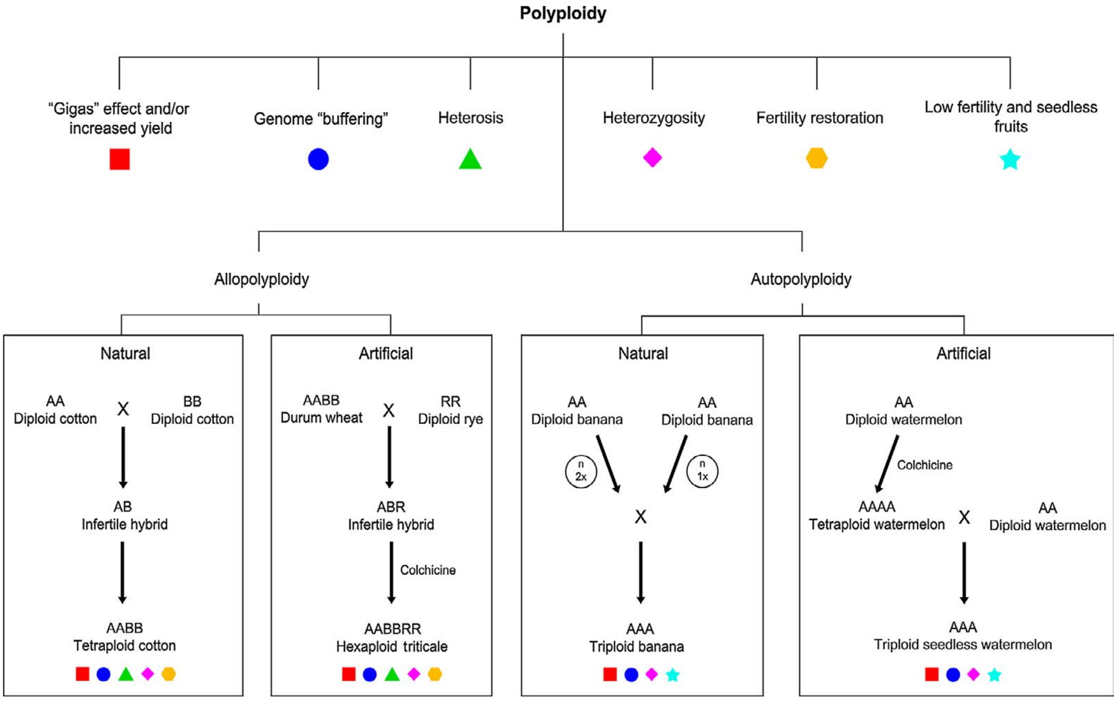

Figure 1: Schematic representation of four cultivated species and some of the main polyploidy consequences for application in crop improvement.

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ornamental, forage crop and fruit breeding. For example, through induced polyploidy, breeders have developed Bouschet tetraploid grapes with more yield and juice content than the diploid progenitor Alicante. The slower growth rate of polyploids allows them to flower later and for a longer period than their diploid progenitors [28].

Production of apomictic crops

Apomixes provides an avenue for the production of seeds asexually through parthenogenesis. Most apomictic plants are polyploid but most polyploid plants are not apomictic (Otto and Whitton, 2000). Obligate apomicts are the most desired of hybrids but little gain has been realized towards their development. However, it has been suggested that obligate apomicts may be induced through development of very high ploidy plants (Levin, 1983). An example of an obligate apomict achieved at high ploidy level is the octoploid of the grass (Levin, 1983).

Mechanisms of polyploidy formation

Polyploidy arise when a rare mitotic or meiotic catastrophe causes the formation of gametes that have more than one set of chromosomes (Comai, 2005). Different mechanisms have been proposed to explain how polyploids arise in nature. Two major pathways are known to lead to polyploidy in plants: somatic doubling and formation of unreduced reproductive cells. Several cytological mechanisms are known to spontaneously induce polyploidy in plants (Ramsey and Schemske, 1998). Diploid gametes, which arise infrequently, typically fuse with haploid ones and produce triploid zygotes, which are unstable and can either be sterile or contribute to further polyploid gametes, depending species (Comai, 2005).

The subsequent union of reduced and non-reduced gametes leads to the formation of polyploids (Acquaah, 2009). Furthermore, autotetraploids may be formed in a diploid population through the union of two unreduced 2n gametes as was found in the F1 progenies of open-pollinated diploid apples (Ramsey and Schemske, 1998). The fusion of diploid gametes leads to tetraploid zygotes, which are potentially stable (Comai, 2005). Another major route for polyploid formation is through somatic doubling of chromosomes during mitosis. In nature, the formation of polyploids because of mitotic aberrations has been reported in the meristematic tissue of several plant species including tomato and in non-meristematic tissues of plants such as bean (Ramsey and Schemske, 1998). Similarly, spontaneous allotetraploids were formed in 90% of F2 progenies of interspecific crosses between ornamentals crop plants (Ramsey and Schemske, 1998). Another example is the formation of autohexaploid Beta vulgaris (sugar beet) and alfalfa from cultivated autotetraploid varieties apparently from the union of reduced (2x) and unreduced (4x) gametes.

Artificial inducement of polyploids through the inhibition of mitosis is routine in plant breeding. High temperatures above 40°C have been used to induce tetraploid and octoploid corn seedlings albeit with low success of 1.8% and 0.8% respectively (Randolph, 1932). Currently, chemical mitotic inhibitory agents such as colchicine or dinitroanilines are used to induce polyploidy in crop plants. A typical example is the production of tetraploid watermelon plants for the production of seedless triploid watermelon (Compton et al., 1996) (Figure 2) [29].

Role of polyploidy in plant evolution

Rates of diversification may be higher in polyploid lineages than in diploid groups (due either to increased rates of speciation, decreased rates of extinction, or both). Polyploidy (the complete doubling of a genome) has long been recognized as an important mechanism of plant speciation and genome evolution. As many as 70% of angiosperm species show signs of polyploidy in their history (Masterson, 1994). Becoming and remaining polyploid changes the organization and function of the genome at both genetic and epigenetic levels. For example, in addition to the creation of gene redundancy, polyploidy causes nuclear enlargement and increases the complexity of the

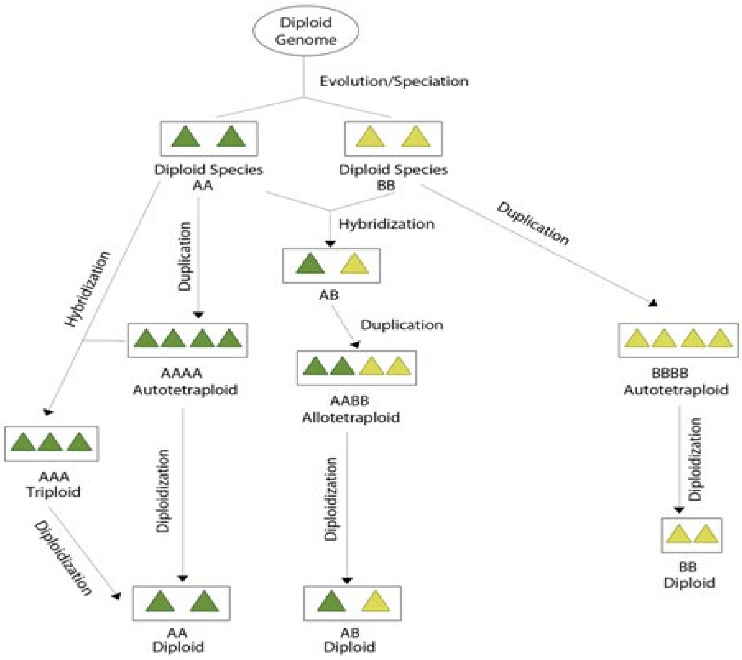

Figure 2: Major pathways in the formation of polyploids.

processes that are involved in managing and partitioning chromosomes during cell division. In addition, several paleopolyploidies seem to be associated with increases in plant diversity, for instance in Asteraceae, Brassicaceae, Cleomaceae, Fabaceae, Poaceae and Solanaceae, and it has been suggested that polyploidy could be a significant cause of elevated rates of diversification in `plants. In comparison to the gradual evolutionary process whereby species evolve by small spontaneous mutations accumulated over time in the population, new species of plants can also arise rapidly.

Multiples of chromosomes in the genomes of some species, a rich debate on the role of polyploidy in plant genetics and evolution has ensued. The most common mechanism for abrupt speciation is through the formation of natural polyploidy. Tetraploids that cross with diploids of the parental species will result in triploids that are typically sterile. This phenomenon provides reproductive barrier between the polyploid and the parental species which is a driving force for speciation. Various estimates suggest that about 47-70 % flowering plants are of polyploidy origin [30].

Conclusion

Polyploidy is a prominent force of shaping the evolution of plants, mostly in ferns, and flowering plants. Many of the crop plants are obviously polyploidy i.e., cotton, wheat, potato, alfalfa, etc. while the some others retain the vestiges of ancient polyploidy events (paleopolyploid) i.e., maize, soybean, cabbage etc. Though polyploidy got attraction initially due to their unique cytogenetics and their reproductive isolation, it was soon recognized that polyploidy also exhibited distinctive phenotypic traits and hybrid vigor useful for agriculture.

The polyploidy species formed independently from heterozygous diploid progenitors may provide important source of genetic variation. Polyploidy generally differ markedly from their progenitors in morphological, ecological, physiological and cytological characteristics that can contribute both to exploitation of a new niche and to reproductive isolation. Thus, polyploidy is a major mechanism of adaptation and speciation in plants (Clausen et al., 1945). Already many of successful evidence have been developed. However, there are still a lot of mystery are in the hide. It is the polyploidy breeding through which new crops can be developed, interspecific genes can be transferred, and the origin of crops can be traced. Though there is many chances of revealing of undesirable characters and may have to face with several challenges, polyploidy breeding will reveal many of mysteries of the plant. It is now an interesting field of study to reveal the evolution of crop plants and utilizing their variability in the field of crop breeding.

Generally, parental DNA sequencing, gene silencing, maternal and paternal effects, larger ecological adaption, and more heterozygosity determine Polyploidy success. Domestication, natural selection, and artificial section of polyploids have resulted in a higher percentage of polyploidy plants in nature, as well as several popular and highly productive plants. Polyploidy plants have more genomic and genetic diversity than other plants. Early varieties, seedless fruits, sterile lines, productive crops, resistance, and therapeutic plants are all possible with polyploidy plants. As a result, polyploidy not only combats hunger, but also alleviates poverty. Polyploidy is also important for humans, as evidenced by the fact that many of the most important crop species are polyploidy. The numerous effects of polyploidy found in natural populations have piqued plant breeders' interest in using artificial polyploidy as a crop enhancement strategy.

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