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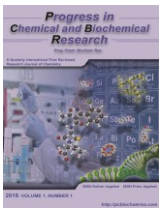

Sex Determination in Papaya: A mini review

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GRAPHICAL ABSTRACT

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ABSTRACT

There is an intriguing system for sex determination in Carica Papaya. To explain the genetics of the Papaya's sex determination there were many hypotheses based on information and knowledge from time to time. Such information and knowledge were about a generic balance of sex autosomes and chromosomes, Classical XY Chromosomes. Nowadays determination of molecular level through genomic technology is possible. Predicted hypotheses can be proving by high density linkage mapping. It shows that with small specific region (MSY) of Y chromosome sex determination can be controlled by a pair of primitive sex chromosomes. It proves that two sex determination genes can control the whole pathway of sex determination. Feminizing or stamen suppressor gene, cause absorption before a flower inception with other while masculinising or carpel suppressor genes cause carpel absorption at the development stage of the flower. To reveal the structural details of sex determination region and sequencing of candidate sex determination genes physical mapping is essential. This process can be observed while papaya production.

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1. Introduction

Papaya can be cultivated in tropical and subtropical regions worldwide. It belongs to caricaceae family that have 6 genera and 35 species in which two are trioecious, one monoceous and 32 are diocious. It is fast growing tree produced fruit whole year after flowering .It provides vitamins such as A or C, nutrious like potassium, thiamine, iron, calcium and fiber etc. It also contains proteotic enzyme papin with its hydrolysing beer peptides.

Papaya is a peculiar model system for genetic research because of its peculiar properties. Papaya consists of none pairs of chromosomes in diploid. By micro – propagation in tissue culture or including root from cutting, vegetation propagation possible. Usually papaya is tricious with three sex form male, female, and hermaphrodite. The characteristics of male tree are long and many flowered, while female trees are small and less flowers whereas hermaphrodite bearing bisexual flowers that can be variable [1-4]

Sex for papaya is inherited its legacy due to lethal factor of male dominant alleles. (Table1 & Fig. 1)

Hermaphrodite and female segregated from the seed of selfed hermaphrodite. Seeds from female segregated in 1:1 ratio into hermaphrodite and female. Male trees produced when hermaphrodite selfed fertilize female trees [5-7].

Hermaphrodite proves to be more productive in many region of the world, as it produces food swiftly where as female involves loss of 6 to 10% in field space. Contrary in cool winter's female production, it preferred, because it is stable at low temperature while others are tend to fuse anthers. The problem which persist in cultivation of papaya is that lack of true breeding varieties [7].

To obtain sex ratio conducive to optimal to productivity; it is needful to germinate a minimum 5 seedling per hill to assure there are no more than 3% female trees. It takes 4 to 6 month to determine the sexes .Such process inefficient of time, labour, water and nutrients and also result in a delay production due to competition among the plants. In early growth contrary production depended on the female trees, germinate four seedlings on female per hill to keep 6 to 10% male trees [8].

In this paper, researcher not only presented three sex types sex but also frequent sex reversal caused by environmental factor. Which is possible through genomics and biological molecular so this through light on the sex determination in papaya and increase our current knowledge regarding genomic and molecule evidence [8, 9].

2 HYPOTHESES

There were so many problems of biology and economic caused by segregation of sex types in the sex determination of papaya .

Fig. 1. The flowers and fruits of male, female, and hermaphrodite papaya. (A) Female flowers; (B) hermaphrodite flowers; (C) male flowers; (D) female fruit; (E) hermaphrodite fruit; (F) male tree

Table 1. Sex Ratio of Crosses between Different Sex Type

crosses	sex ratio			
	female	male	Hermaphrodite	Non- visible
Male(Mm)	1	2	0	1
Female(Mm) × Male(Mm)	1	1	0	0
Hermaphrodite (M^hm)	1	0	2	1
Female(Mm) × Hermaphrodite (M^hm)	1	0	1	0
Hermaphrodite (M^hm) × Male (Mm)	1	1	1	1

following hypotheses throws lights on partial revelation into the nature or sex determination in papaya.

*2.*1 There will be no genetic balance between sex chromosomes and autosomes.

In this hypotheses, it was assumed that female sex determination factor predominate the sex chromosome, are in the autosome.

It was further assumed that M and M^h and M aculeles were set chromosome. It was also supposed that female sex determining factors are in the autosome which means M and M^h represent an inactivated genes were elimination,but that the inactivated region represent by M^h.

In conclusion, each sex chromosome and the autosome to come up with quantitative representation of the genic balance which does not support to hypotheses .Thus, we can say that there was genicbalance between sex chromosome and autosome which is not accepting the hypothesis [9-13].

2.2 Sex determination behaves as multi genes with multi aucels .

Segregation or sex of three type of papaya shows that sex determination in papaya controlled by single gene with three aucles named as M_1 , M^h and M by storey's designation from male aucle M. Male individuals (M^h,M) are and hermaphrodite (M^h,M)

are hetereougous whereas female individuals (M,M) are homozygous recessive the dominant combination of MM , M^hM^h and MM^h are lethal, resulting in a 2:1 segregation of hermaphrodite to female from self pollinated hermaphrodite seeds which not support the give hypothesis.

2.3. X and Y Sex Chromosome System with two Slightly Different Y Chromosome

Based on intergeneric hybridizations between *Carica* and *Vasconcellea* species, Horovitz and Jimenez [14, 15] proposed that sex determination in

papaya is of the XX-XY type. The genotypes of male, female, and hermaphrodite were XY, XX, and XY2, respectively. These researchers suggested that the chromosome Y has a region containing a lethal factor. In their hypothesis, Y2 is a modified form of the Y chromosome but includes the region of lethality.

3. Molecular Genetics of sex determination in papaya

Sex linked DNA markers were developed by several research groups and linkage constructed. High density genetic mapping fine mapping,physical mapping and DNA sequencing of the sex determination locus led to the result that a pair of primitive sex chromosome controls sex determination in papaya .

3.1 Sex linked DNA markers

In 1990s,it becomes priority make sex linked markers of DNA to test sex type in papaya then after DNA marker were widely used in papaya sex determination .On contrary in olden day papaya researchers and producers have long markers methods and techniques the first sex inked marker was found microsatellite containing the quandra nuclueotide repeats,$(GATA)_4$ [16-19]. Polymorphic DNA (RAPD) was used to screen sex linked marks in SCAR (Sequenced characterized amplified region) [20-22].

3.2 Fine mapping of the sex determination locus

It was a high density mapping project because sex linked SCAR Markers were available .So Chromosome containing the sex determination gene appeared to recombine normally .Such project content of 2190 females and hermaphrodite plant from three F_2 and F_3 population, the two SCAR markers ,three carica papaya (cloned) sex linked AFLP markers, and one BACC(bacterial artificial chromosome) were in the process. Despite of such screen and mapping process even not a single recombination was detected [19-22]

3.3 Primitave sex chromosome system

Sex determination locus depends on combination of physical mapping, genetic mapping, and DNA sequencing. Such recombination of methods around sex determination locus leads to gradual degeneration of the Y chromosome as shown **Fig.2** [23-27] . Such will be resulted in heteromorphic sex chromosome [28, 29] sequencing X and Y gene pair allows us to estimated the age of sex chromosome in papaya and confirm its of its origin in papaya sex chromosome .

4. Current understanding of sex determination in papaya.

Sex determination in papaya depends upon the evolved sex chromosomes of pairs. Y chromosome rein force the heterozygosis by degenerating survival of the homogonous YY geno type as we know there are two different Y chromosome in papaya .Y-male specific chromosome in male

papaya and Y^h in hermaphrodite papaya because of two Y chromosome closely identical [9, 12].

.Another mutation female lethality was a documented recently [28-30]. which degenerates regulatory element causing embryo abortion on the Y and Y^h chromosome.

in the process of sex determination two genes are involved ,stamen suppressor or feminizing gene for stamen abortion in female flower and other carpel suppressor or masculinising gene for carpel abortion in male flower .

the male sex determination gene is likely a downstream regulator that aborted the couples a letter development stage. With accumulated genetic and molecular data on papaya sex chromosomes, we can now better explain earlier hypothesis the male specific region of the Y chromosomes behave like single genetic unit since there is no recombination. Thus MSY considered as giant locus acting as a single gene with three cells. 1938, storey's hypotheses make sense.

5. Towards cloning the sex determination genes in papaya

There was no usual option of identifying sex determination through a map based cloning approach because of no recombination of MSY region.

It was essential to attempting to clone the sex determination genes to complete the sex determination sequence of MSY and X chromosomes to further analysis X chromosomes and MSY differentiated region was combined sex reverse Y deletion lines could not be valuable for narrowing the list of candidate genes.

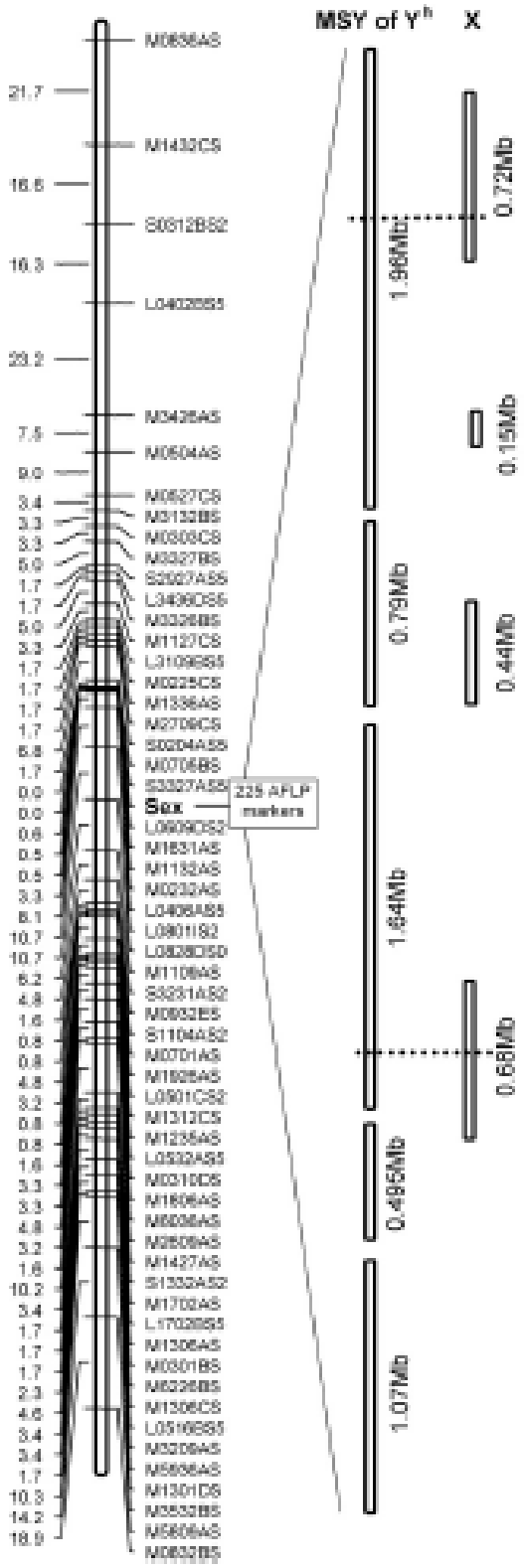

Fig. 2. recombination of methods around sex determination locus leads to gradual degeneration of the Y chromosome.

We have produced a few Y deletion lines using Y-ray irradiation of papaya.

6. Conclusions:

Thus, this mini review throws light on possibility of determination of molecular level, through genomic technology. Predicted hypotheses can be proved by high density linkage mapping. It shows that with small specific region (MSY) of Y Chromosomes sex determination can be controlled by a pair of primitive sex chromosomes. It proves that two sex determination genes can control the whole path way of sex determination genetic mapping research which include Y pair of diploid chromosomes.

Conflict of interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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