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Theme 4. Biodiversity, conservation and genetic improvement of range and forage species

Sub-theme 4.1. Plant genetic resources and crop improvement

Ploidy dependent expression of apomixis components in guinea grass (*Panicum maximum* Jacq.)

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Introduction

Apomixis is an asexual method of reproduction through seeds. The potential of apomixis has been envisaged as “asexual revolution” by virtue of its capacity to fix hybrid vigour, a much desirable feature in breeding of agricultural crops. The genetic mechanism of apomixis regulation is complex and is believed to be largely affected by polyploidy (Nogler 1984). Expression of apomixis essentially contains three components, viz. apomeiosis (formation of unreduced egg cell), parthenogenesis (fertilization independent embryo development) and functional endosperm development (autonomous or pseudogamous). In contrast to previous reports, the evidence has now gathered that these three components can be functionally uncoupled and recombination is possible between these components (Kaushal, *et al.*, 2008). Such recombinations lead to diversity in seed development pathways and also provide a mechanism to modify the ploidy levels. Uncoupling of apomeiosis from parthenogenesis may yield high frequency of triploids and haploids. Utilizing this partitioning principle we have generated a ploidy series following a Hybridization–supplemented Apomixis-components Partitioning Approach (HAPA) in guinea grass, a model crop for polyploidy and apomixis research, (Kaushal *et al.*, 2009). From a single 4x (2n=32) progenitor, a ploidy series has been developed represented by 3x, 4x, 5x, 6x, 7x, 8x, 9x and 11x cytotypes. This ploidy series offers advantage of studying ploidy regulated gene expression. There have been sporadic reports on effect of polyploidy in expression of apomixis per se; however information on effect of polyploidy on individual apomixis components is not available. The guinea grass ploidy series with sequentially added monoploid genome doses has been used in present study to understand the effect of ploidy levels on phenotypic expression of partitioned apomixis components.

Materials and Methods

28 lines of guinea grass (*Panicum maximum* Jacq.) representing various ploidy levels viz. 3x (1 line), 4x (4 lines), 5x (3 lines), 6x (10 lines), 7x (1 line), 8x (2 lines) and 9x (7 lines), developed through HAPA were subjected to studies on phenotypic expression of apomixis and components. All the lines were characterized for their mode of reproduction following methyl salicylate mediated ovule clearing, whole mount observed under DIC microscopy following Young *et al.*, (1979). Eight nucleated embryo sacs (ES) containing 2 synergids, 1 egg cell, 2 polar nuclei and 3 antipodals were considered as sexual ES, while aposporous ES were 4 nucleated (2 synergids, 1 egg cell and 1 polar nuclei) (Warmke, 1954). Plants with all sexual or aposporous ES were termed as obligate sexual or aposporous, respectively, while those with representation of both types of ES were considered as facultative.

The partitioning of apomixis components and their expression was estimated by Flow Cytometric Seed Screen (FCSS) following Kaushal *et al.*, (2009). Proportion of seeds containing triploids (3n), arising through 2n+n hybridization (B_{III} hybrids) and/or haploids (M_I) arising through (n+0) development in a seed lot collected through self-pollination from each line individually were used as a measure to estimate occurrence of partitioned apomixis components viz., apomeiosis and parthenogenesis. Single seed FCSS was performed with individual mature seeds from all plants representing ploidy series.

Results and Discussion

Apomixis expression has been known to be influenced by ploidy levels (Carman 1997, Quarin *et al.*, 2001). In view of the recent reports on recombination and independent existence of apomixis components, it becomes important to study the effect of ploidy on expression of individual apomixis components. One of the approaches used here was to use a ploidy series developed through HAPA in guinea grass. Recombination between apomixis and parthenogenesis components may allow uncoupling of these two traits and eventually the unreduced egg cell will lose the capacity of parthenogenesis and will require fertilization for development of embryo thereby yielding 3n embryos (B_{III}, 2n+n). Alternatively, a meiotic egg cell will acquire parthenogenetic capacity and will develop into a haploid (M_I, n+0). How far these uncoupling events are influenced by ploidy levels, were studied in this experiment.

Mode of female reproduction of different lines representing various ploidy levels is represented in Table 1. Lines representing 3x and 4x cytotypes were all obligate aposporous in female reproduction, 7x, 8x and 9x cytotypes were facultative aposporous, while 5x and 6x cytotypes were represented by both obligate and facultative reproduction behavior. These cytotypes showed wide range of variation in their expression of partitioned apomixis components. Range as high as 0-43% in B_{III} production and 4-21% in M_I production has been observed. This variation in expression of partitioned apomixis components can be attributed to genotypic differences within a ploidy level. No clear cut correlation could be observed between enhancements in frequency of B_{III} hybrids over ploidy raise; however, it was very evident that increase in ploidy had positively affected the expression of M_I seeds. As evident from Fig 1., it was noted that expression of parthenogenesis (M_I production) has increased from 6x till 9x in a linear fashion, however required a minimum level of ploidy to initiate the expression, as no M_I was observed in plants representing lower ploidies i.e. 3x, 4x and 5x.

The studies clearly indicated the effect of ploidy on phenotypic expression of apomixis component traits. While higher ploidies effect formation of both B_{III} and M_I hybrids, a minimal level of threshold ploidy was found to be essential for expression of partitioned parthenogenesis component. Ploidy regulated expression of key genes involved in reproductive pathway is underway to correlate phenotyping data with expression analysis in view to identify genes modulating in response to mode of reproduction and change in ploidy.

Table 1: Mode of female reproduction *vis-a-vis* ploidy level

Ploidy (x)	2n=	No. plants	Mode of reproduction		Range (%)		Average (%)	
			Obl Apo	Fac Apo	B _{III}	M _I	B _{III}	M _I
3x	24	1	1	-	20	0	20.0	0.0
4x	32	4	4	-	0-16	0	9.0	0.0
5x	40	3	2	1	0-42.9	0	15.4	0
6x	48	10	3	7	0-34.6	0-6.5	14.5	1.4
7x	56	1	-	1	29	3.2	29	3.2
8x	64	2	-	2	8.1-9.4	2.7-14.5	13.7	8.6
9x	72	7	-	7	6.7-23.9	4.0-21.2	14.2	10.5

Obl Apo: Obligate apomictic; Fac Apo: Facultative apomictic

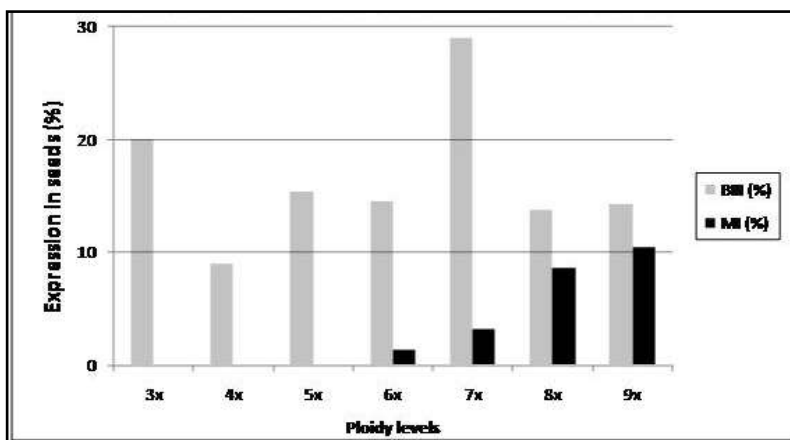


Fig. 1: Average expression of apomixis components over ploidy level

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