ASSESSING THE GENOTYPIC DIFFERENCES FOR SEED SET AND SEED ABORTION IN TOMATO GENOTYPES

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ABSTRACT

Tomato (*Lycopersicon esculentum* Mill.) is one of the most popular fruit vegetable around the world. Seed abortion where in only a small proportion of ovules in an ovary develops into matured seeds, is a wide spread phenomenon in multi-ovulated species. In agriculturally important crops such as chickpea, groundnut, Brassica, pigeon pea and field bean seed abortion substantially reduces their productivity. Tomato genotypes exhibited seed abortion where in only some proportion of ovules developed into matured seeds. Seed abortion in tomato cultivars would increase the cost of hybrid seed production. In this study, we have analyzed 19 genotypes for number of ovules, seed set and seed abortion. Tomato genotypes differed significantly for number of ovules per ovary, seed set per fruit and per cent seed abortion. The ovules, matured seeds and seed abortion ranged from 52 to 412 per ovary; 50.90 to 240.76 per fruit and 6.06 to 24.44 per cent respectively. Strong positive correlation was observed in genotypes with higher number of ovules showed higher percentage of seed abortion.

Key words: Tomato, genotypic difference, ovules, matured seeds and seed abortion

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INTRODUCTION

Intra-fruit seed abortion has been a vexing problem affecting the productivity of several agricultural and commercial crops and the reproductive potential of the range of wild plant species. While in the agricultural crops such as red gram, ground nut, field bean, and perennial crops such as tamarind, pongamia seed abortion directly affects the yield levels, in commercial crops such as tomato, chilly, cotton etc., seed abortion reduces the efficiency of hybrid seed production in seed production plots. In wild plants, seed abortion is known to be recurring phenomenon costing to the fitness. Thus understanding the factors regulating seed abortion has become an important area of research both in improving the crop yields and in understanding the reproductive ecology of wild plants.

The purpose of the present study was to know the genotypic variation for seed abortion across accessions. Intra-fruit seed abortion was been generally attributed to either resources limitation (Willson and Schemske 1980; Stephenson 1981; Udovic and Aker 1981; Lee and Bazzaz 1982; Wiens 1984; Lee and Bazzaz 1986; Zimmerman and Pyke 1988) and/or to lack of pollen and fertilization (Snow 1982; McDade 1983; Wiens 1984; Mikesell 1988; Zimmerman and Pyke 1988; Lalonde and Roitberg 1989; Whelan and Goldingay 1989). However, in recent years, several studies have shown that this abortion in many plant species occurs consistently over years and locations (Casper and Wiens 1981; Arathi 1990) and is not due to pollen (Casper 1983; Uma Shaanker and Ganeshaiah 1984; Guth and Weller 1986; Ganeshaiah and Uma Shaanker 1988; Uma Shaanker et al. 1988) and/or resources limitation (Ojehaman 1970; Ho 1980; Michale and Berringer 1980; Bawa and Webb 1984; Ganeshaiah and Uma Shaanker 1988; Chalapathy Reddy et al. 2009). Other authors have pointed out that many plants are likely to be limited by both resources and pollen and complex interactions between resources and pollen availability can occur. For example, plants can be limited by resources when pollen is abundant or limited by pollen when a resource is abundant (Casper and Niesenbaun 1993). Alternatively, resources and pollen might affect different components of reproduction, such as when resources primarily affect ovule production, and pollination primarily affects the proportion of ovules that develops into seed (Campbell and Haloma 1993). In this study, we analyzed intra-fruit seed abortion patterns in tomato genotypes.

MATERIAL AND METHODS

Nineteen tomato genotypes were collected from the tomato breeding centre, Department of Genetics and Plant Breeding, University of Agricultural Sciences (UAS); these genotypes were consisted of cultivated, improved varieties and other germplasm accessions. These were grown under all recommended package of practices in, Hebbal Farm, UAS, Bangalore. After anthesis, the young 10 flowers from each genotype were collected and ovule count was taken present in each ovary. The seeds were also counted at 25 days after anthesis (DAA) and at maturity by cutting the fruit into three equal parts (*viz*. Pedicel, Middle and Stylar) and seeds were classified into developed and developing (at 25 DAA) and mature, immature and dead seeds (at maturity). The seed pool at 25 DAA and maturity consists of developed and developing seeds; matured, immature and dead seeds respectively. The developing seeds at 25 DAA; immature and dead seeds at maturity considered as aborted seeds and accordingly per cent seed abortion were computed.

RESULTS AND DISCUSSION

Tomato genotypes differed significantly for the number of ovules per ovary and this per se appeared to contribute significantly to the number of seeds set in the fruits as indicated by the significant positive correlation between these two parameters (Figure 1). In other words, the number of seeds set in the fruits of a genotype is determined largely, by the ovules in the ovaries of the genotypes. The number of ovules in the ovary appears to be shaped by the process of unintended selection under domestication for increased seed number. For instance the wild relative, *L. hirsutum* had only 46 seeds (from 52 ovules per ovary) while some of the improved lines such as Arka abha, Arka megali etc had ovules and seeds in the highest range among the genotypes. Nevertheless domestication does not appear to have brought about a significant increase in the proportion of ovules maturing; the per cent seeds that matured from the total seed pool at maturity was negatively correlated with the number of ovules (Figure 2, r = -0.64; $p<0.01$); the wild accession had the highest per cent of ovules maturing to seeds (90 per cent; Table 1) while the most genetically improved lines such as Arka abha, Pusa ruby etc had lowest range of the proportions of the ovules or seed pool maturing to seeds.

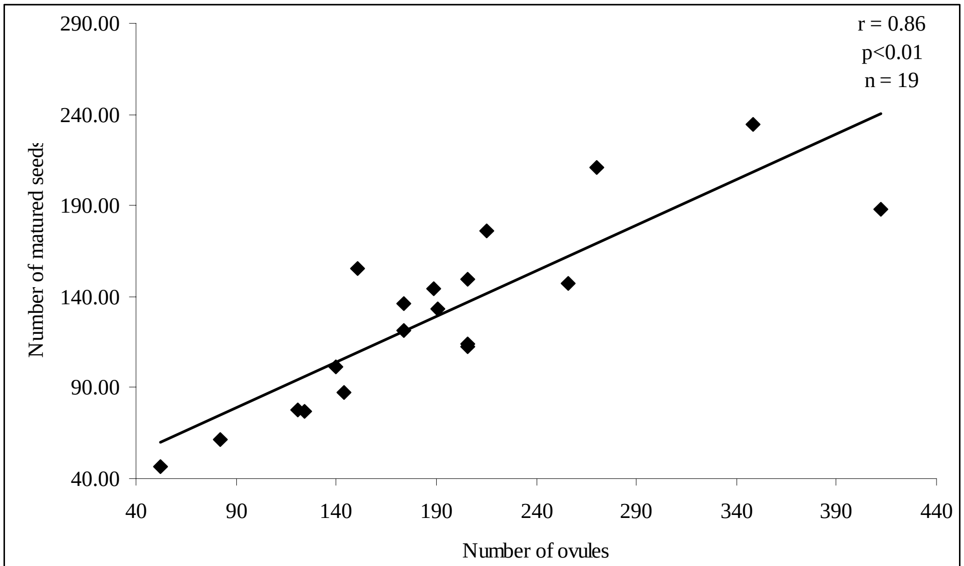

Figure 1 Relationship between number of ovules and matured seeds in 19 tomato genotypes.

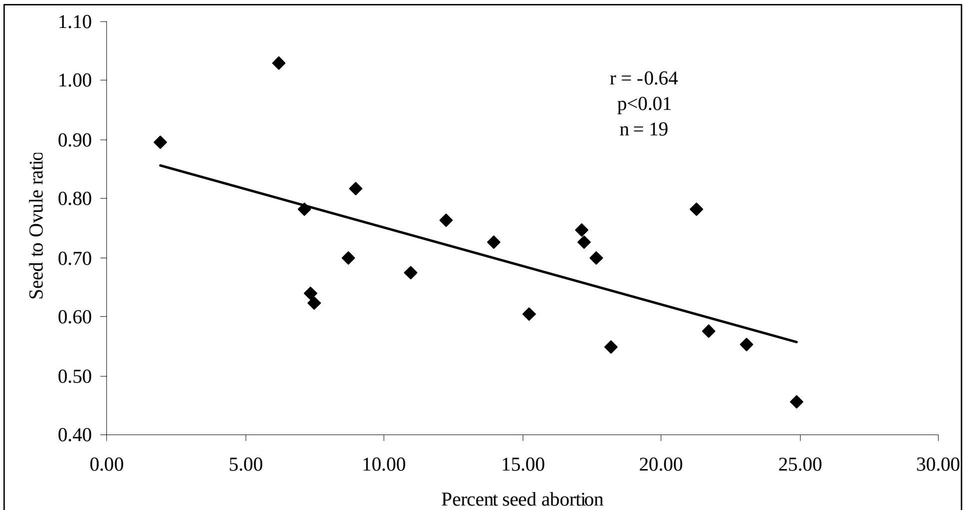

Figure 2: Relationship between percent seed abortion and seed set to ovule ration in 19 tomato genotypes

Table 1: Genotypic variation for mean number ovules per ovary, seed pool, developing seeds per fruit and per cent abortion during 25 DAA in 19 genotypes

Sl.No.	Genotypes	Mean ovules per ovary ± SE	Mean seed pool per fruit ± SE	Mean developing seeds per fruit ± SE	Per cent seed abortion
1	Arka abha	412.00 ± 16.14	194.34 ± 9.31	47.34 ± 2.42	32.20
2	Arka megali	270.00 ± 18.77	219.42 ± 9.36	49.12 ± 4.91	28.84
3	BWR	206.00 ± 17.29	116.63 ± 1.72	21.86 ± 2.02	23.06
4	Co-1	206.00 ± 09.18	191.69 ± 6.05	30.95 ± 1.48	19.25
5	Co-2	348.00 ± 22.96	240.76 ± 12.10	38.67 ± 1.51	19.14
6	Co-3	189.00 ± 09.99	179.83 ± 2.52	22.83 ± 0.86	14.54
7	*L.hirsutum*	052.00 ± 01.88	050.90 ± 3.29	03.10 ± 1.17	6.49
8	PKM	215.00 ± 10.75	189.95 ± 6.74	25.93 ± 2.48	15.81
9	Pusaruby	191.00 ± 11.74	137.59 ± 9.93	25.05 ± 4.71	22.26
10	Shakthi	140.00 ± 09.91	108.60 ± 6.94	20.70 ± 2.08	23.55
11	Shapard	206.00 ± 17.18	159.56 ± 9.22	39.00 ± 2.75	32.35
12	Sonali	256.00 ± 9.91	198.88 ± 13.93	46.00 ± 1.56	30.09
13	TLB 111	121.00 ± 07.57	119.66 ± 5.54	12.86 ± 1.82	12.04
14	TLB 119	082.00 ± 04.92	064.80 ± 3.96	05.60 ± 1.47	9.46
15	TLB 129	151.00 ± 05.23	121.08 ± 6.11	11.08 ± 2.81	10.07
16	TLB 130	194.00 ± 06.34	127.85 ± 6.27	10.05 ± 4.46	8.53
17	TLB 134	174.00 ± 07.52	138.00 ± 7.00	02.10 ± 0.48	1.55
18	V-13	124.40 ± 04.15	075.55 ± 1.77	06.09 ± 0.81	8.77
19	V-14	143.60 ± 06.46	105.99 ± 2.42	07.10 ± 0.76	7.18
	Mean	192.68	144.28	22.39	17.11
	SE	18.75	53.25	15.75	9.23

Table 2: Genotypic variation for mean number ovules, seed pool, matured, immature, dead seeds and per cent seed abortion in 19 tomato genotypes

Sl. No.	Genotypes	Ovules per ovary ± SE	Seed pool per fruit ± SE	Matured seeds per fruit ± SE	Immature seeds per fruit ± SE	Dead seeds per fruit ± SE	Percent Abortion
1	Arka abha	412.00 ± 16.14	235.00 ± 11.46	188.13 ± 10.30	09.53 ± 1.46	37.33 ± 4.80	24.91
2	Arka megali	270.00 ± 18.77	256.08 ± 17.04	211.16 ± 13.87	13.58 ± 2.97	31.33 ± 4.16	21.27
3	BWR	206.00 ± 17.29	133.36 ± 12.44	112.82 ± 11.37	08.18 ± 1.10	12.36 ± 1.77	18.21
4	Co-1	206.00 ± 09.18	170.74 ± 12.19	149.81 ± 12.29	05.64 ± 0.63	15.29 ± 1.27	13.97
5	Co-2	348.00 ± 22.96	260.66 ± 20.49	234.85 ± 19.15	07.68 ± 1.07	18.13 ± 1.97	10.99
6	Co-3	189.00 ± 09.99	161.91 ± 09.44	144.23 ± 08.83	03.67 ± 0.41	14.05 ± 1.08	12.26
7	*L.hirsutum*	052.00 ± 01.88	47.50 ± 02.42	046.60 ± 02.37	00.10 ± 0.10	00.80 ± 0.19	1.93
8	PKM	215.00 ± 10.75	191.54 ± 07.39	175.77 ± 06.77	05.00 ± 0.73	10.77 ± 0.87	8.97
9	Pusa ruby	191.00 ± 11.74	157.08 ± 07.51	133.50 ± 05.74	08.42 ± 2.58	15.17 ± 1.63	17.67
10	Shakthi	140.00 ± 09.91	119.10 ± 05.42	101.60 ± 05.41	07.10 ± 0.67	10.40 ± 0.76	17.22
11	Shapard	206.00 ± 17.18	139.92 ± 05.83	113.67 ± 06.32	11.67 ± 1.52	14.58 ± 1.68	23.09
12	Sonali	256.00 ± 9.91	179.30 ± 09.23	147.30 ± 08.66	12.20 ± 2.31	19.80 ± 2.57	21.72
13	TLB 111	121.00 ± 07.57	083.10 ± 05.48	077.40 ± 05.06	02.50 ± 0.45	03.20 ± 0.36	7.36
14	TLB 119	082.00 ± 04.92	071.70 ± 01.88	061.20 ± 02.67	05.60 ± 0.81	04.90 ± 0.94	17.16
15	TLB 129	151.00 ± 05.23	132.34 ± 04.38	121.70 ± 04.34	03.00 ± 0.40	07.64 ± 0.64	8.74
16	TLB 130	194.00 ± 06.34	165.00 ± 07.43	155.38 ± 07.16	02.92 ± 0.36	06.70 ± 0.96	6.19
17	TLB 134	174.00 ± 07.52	145.60 ± 08.09	135.90 ± 07.31	02.10 ± 0.28	07.60 ± 0.82	7.14
18	V-13	124.40 ± 04.15	083.10 ± 09.60	077.30 ± 08.95	02.80 ± 0.64	03.00 ± 1.20	7.50
19	V-14	143.60 ± 06.46	100.36 ± 22.04	087.09 ± 19.21	04.18 ± 1.56	09.09 ± 1.85	15.24
	Average	192.68	149.13	130.28	6.1	12.74	13.77
	SD	85.87	59.56	50.08	3.77	9.28	6.55

Seed abortion pattern and causes for seed abortion

The genetic differences among the genotypes for the seed set ratios can not be attributed to the resource and pollen limitation, the two major proximate factors generally argued to be causing seed abortion in plants. Since all the genotypes were grown under the similar environmental and management conditions, the resource and pollen availability could not have been brought about by the external or environmental conditions. However, there could be genetic differences for the extent of internal (intra-plant) resources made available for the development of the fruits within each genotype. Similarly, differential seed abortion among the genotypes could be brought about due to the differential genetic quality of the pollen grain in their flowers. Indirect evidence seem to suggest that these possibilities are unlikely: The fruits that suffer from resource limitation are known to exhibit increased seed abortion at the proximal (pedicel) end; on the other hand those suffering from qualitative and or qualitative limitation of pollen grains are shown to exhibit increased abortion at the distant (stylar) part of the fruits. The 19 genotypes studied though differed for the number of seeds set at the pedicel, middle and stylar regions, they did not differ for the proportion of ovules (or of the seed pool) developing to mature seeds at the three positions (Figure 3). Thus, the resource and pollen limitations do not appear to be the major factors causing seed abortion in tomato genotypes.

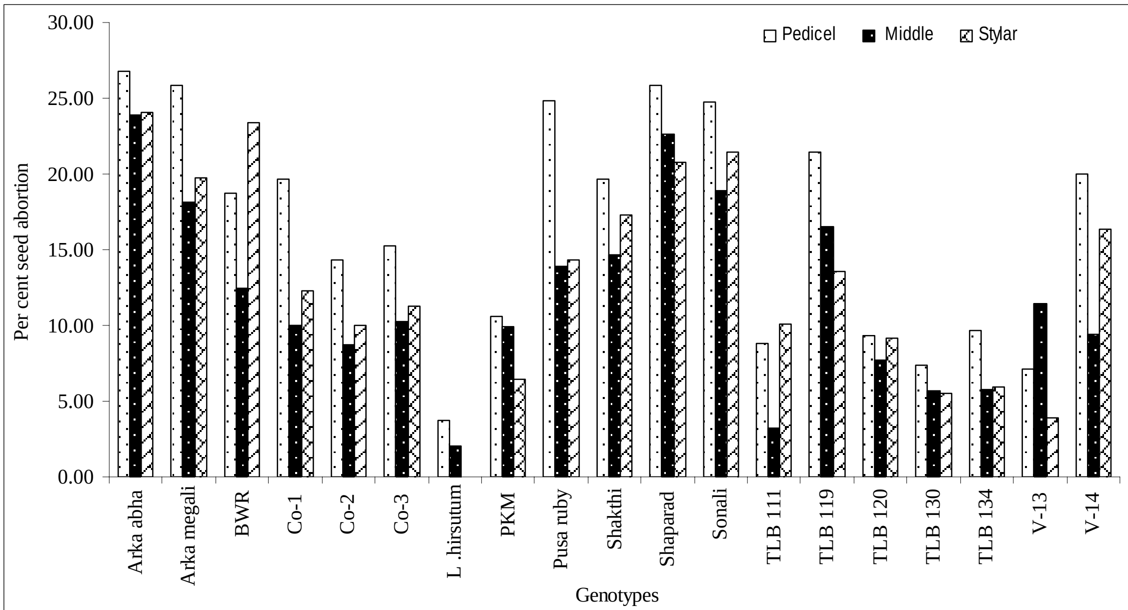

Figure 3. Genotypic variation for positional (Pedicel, Middle and Stylar) per seed abortion at maturity in 19 tomato genotypes.

On the other hand there was a strong suggestion that the observed differences in the seed abortion among the genotypes is perhaps due to the genetic differences in the rates of resource flow to the ovules after fertilization - a process proposed by the concept of the self-organized flow of resources differences. The seed set ratios of the genotypes were positively correlated with the sink drawing ability of their ovules measured by the amount of labeled sucrose taken up by these ovules immediately following fertilization (Chalapathy Reddy et al. 2009).

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