Appendix
Phenomic analyses of Indian and exotic accessions of Sesame (*Sesamum indicum* L.)

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A phenomic approach was undertaken to characterize seventy one accessions of sesame (*Sesamum indicum* L.) procured from India, Venezuela and USDA following the descriptor of NBPGR and IPGRI. The phenotypic traits varied extensively and the degree of polymorphism was highest in case of seed coat colour while few traits exhibited only binary type character state. Morphological observation revealed Venezuelan genotypes as the most derived ones while the Indian accessions, be it under NBPGR or USDA repository possess some of the wild character state of the traits. The hierarchical axial representation of phenogram indicated that one Indian accession under USDA repository (USIN06) was unique while the Venezuelan genotypes fell in a common cluster in neighbour-joining WPGMA tree. Principal coordinate analysis further resolved the relative distances between genotypes within each cluster/sub cluster. The traits related to trichomes of different plant parts showed highest correlation coefficients. A simple homology based algorithm; considering the character states as different colour codes and comparison of the codes of each genotype with that of a postulated ‘target sesame’ resulted in few Indian and exotic accessions of sesame on the basis of high ‘scores’, which will probably lead to a more precise means of selection of genotypes for future marker assisted breeding program.

**Key words:** Phenotypic traits, sesame accessions, phenogram, principal component analysis (PCA).

**INTRODUCTION**

Sesame (*Sesamum indicum* L.) is an age-old yet under-exploited oil seed crop (Laurentin and Karlovsky, 2006). Sesame breeding techniques vary greatly and have evolved from simple plant selection (Kinman and Martin, 1954) to hybrid cultivar development (Quijada and Layrisse, 1995). Revitalization of sesame-breeding methods assisted by marker assisted selection (MAS) could be of great value in breeding superior varieties. Although, sesame is one of the oldest cultivated plants in the world, its production and extension has been limited, particularly because of its low yield (Baydar, 2005). A major contributing factor to low yield in sesame is less emphasis on researches related to yield structure as a basis for progress in sesame breeding. Furthermore, sesame is a typically neglected crop since it is not studied by any of the international agricultural research centers; and the paradigm of sesame parallels many minor crops: sesame is not a major crop because there is little research and other way around there is little research on sesame because it is not a major crop. Of the many important concerns where there remains scope for improvement to obtain a superior plant type of sesame, the most essential one is to accurately determine the time of seed maturity for harvesting. Due to inherent indeterminate nature of sesame the mature capsules near the base of the plant shatter resulting in loss of seeds while flowering continues on the top of the plant. Determinate growth habit in sesame, hence, offers the solution to such difficulties and it is now one of the prerequisites for adapting sesame to modern farming systems. This trait permits synchronized flowering and improved lodging resistance with shorter plant stature. However, on the other hand, in the determinate plant type yield is low compared to indeterminate counterparts (Uzun and Cagirgan, 2009). It is therefore important to improve the determinate types using both conventional and molecular plant breeding strategies. Apart from that, multiple flowers per axil, which will eventually lead to more number of pods – will be an added factor for improving yield of sesame. These traits however, are not

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‘Precocious’ Seed Germination in Turkish and Chinese Accessions of Sesame (Sesamum indicum L.) in Indian Conditions

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Abstract: A ‘precocious’/ ‘viviparous’ seed germination is reported in one Turkish and one Chinese accession of Sesame (Sesamum indicum L., family Pedaliaceae), an oilseed crop, for the first time. Both the mature and green pods of these accessions showed a peculiar ‘within pod’ germination of seeds in pot culture. Scanning Electron Microscopy of the placental zone of the immature pod revealed early cotyledon development of different stages, while magnified views of the germinated seedling from the mature pods depicted onset of multi-cellular trichome and even the stomata. This unique and aberrant phenomenon of seed germination was correlated with environmental fluctuation associated with low dormancy of seeds.

Key words: Sesame • SEM • Vivipary

INTRODUCTION

Sesame (Sesamum indicum L.) is the most ancient oilseed crop known to human civilization as the oldest remnants of sesame, found in the Harappa valley in the Indian subcontinent; date the origin of these activities to at least 5500 BC [1]. The uniqueness of sesame plant is that it continues to produce leaves, flowers and capsules simultaneously as long as the weather permits unlike most other crops where onset of reproductive growth marks the cessation of vegetative growth. This indeterminate developmental phenomenon poses a serious problem in sesame cultivation since it is near impossible to accurately determine seed maturity as mature capsules near the base of the plant split and lose seed while flowering continues on the top of the plant. In fact, it is among the most important priorities for developing an improved plant type of sesame either through classical or marker assisted breeding approach and to convert sesame from a labor intensive crop requiring manual harvesting to a mechanized harvesting-compatible crop. This ‘shattering of seeds’ as a resultant of non synchronous pod maturity though is not preferred from the perspective of sesame breeding and cultivation but from the point of view of the plant itself, this wild trait(s) is of definite advantage to thrive and propagate in unfavorable condition.

While working on an ongoing programme of improvement of sesame through marker assisted breeding for last couple of years, the present group has developed a phenomic based algorithm to characterize seventy one germplasm of sesame procured from different parts of the world and has short listed few Indian and exotic accessions having unique assemblage of traits setting subsequent milestone of looking for genotype and trait specific molecular markers [2]. Two of these selected accessions (one from Turkey-accession number PI 175907 and the other from China-accession number PI 195122; both procured from USDA repository) while grown with the other accessions / varieties in the last season (2011) have shown a unique phenomenon of ‘precocious’ / ‘viviparous’ seed germination, which is being reported here.

MATERIALS AND METHODS

Seeds were sown in the month of March routinely both in field condition and earthen pots within net house. The crops were harvested within May to early June in field condition but the plants grown in pot culture were reared until July, mainly to study the indeterminacy and non synchronous growth habit of the crop critically, one of the major issues of sesame, which has been stated earlier. During the last week of June 2011, plants of both the accessions started to show a peculiar ‘within pod’ germination of seeds (Fig. 1a), which initially was an event of the till then non-shattered seeds within the matured pods.
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IMAGE-ANALYSIS BASED ON SEED PHENOMICS IN SESAME

ABSTRACT

The seed coat (testa) structure of twenty-three cultivated (Sesamum indicum L.) and six wild sesame (S. occidentale Regel & Heer, S. malayanum Nair, S. prustratum Retz., S. radiatum Schumach. & Thonn., S. angustifolium (Oliv.) Engl. and S. chinianum Aich) germplasm was analyzed from digital and Scanning Electron Microscopy (SEM) images with dedicated software using the descriptors for computer based seed image analysis to understand the diversity of seed morphometric traits, which later on can be extended to screen and evaluate improved genotypes of sesame. Seeds of wild sesame species could conveniently be distinguished from cultivated varieties based on shape and architectural analysis. Results indicated discrete 'cut off' values to identify definite shape and contour of seed for a desirable sesame genotype along with the conventional practice of selecting lighter colored testa.

Key words: phenomics, seed image analysis, sesame

INTRODUCTION

Sesame is the oldest oilseed plant used by humans (Weiss, 1983; Mabberley, 1997). It was cultivated during Harappan, Mesopotamian, and Anatolian eras, and throughout the Greco-Roman world, both for its edible seed and for its oil. It was domesticated on the Indian subcontinent (Bedigian, 1984, 1998, 2000, 2003) though report of African origin of sesame is also available (Ihlenfeldt and Grabow-Seidensticker, 1979). It is possible that the genus Sesamum arrived on the Indian subcontinent at a very early period, before Gondwanaland broke apart, transferring sections of the genus to India. It was probably domesticated there later, somewhat after the intro-

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Selection of prospective parents among Indian and exotic Sesame (Sesamum indicum L.) for marker assisted breeding

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Abstract

Five exotic sesame accessions were selected by combined phenomic and genomic approaches as prospective male parents to introgress certain desirable traits as lighter testa colour, synchrony in capsule maturation and non-shattering habit of mature capsules for improvement of one selected Indian accession. One SCAR marker, specific to the female parent (Indian) and certain SSR allelic polymorphism between female and five prospective exotic male parents are reported, which will be helpful for marker assisted breeding of sesame.

Key words: Marker assisted breeding, phenomics, RAPD, SCAR, SSR, sesame

Introduction

Sesame (Sesamum indicum L.) is the third most important oilseed crop of India after groundnut and mustard. At the global level India is the leader with highest production (25.8%), maximum area (29.8%) and highest export (40%) (http://faostat3.fao.org/faostat-gateway/go/to/browse/Q/QC/E). Sesame oil is considered as 'Queen of oils' because of its high nutritional value and health benefits. Yet, its cultivation, because of lack of improved varieties, is not widespread and popular in India. There are certain important concerns which need to be studied to develop improved genotype of sesame suitable for diverse agro-climatic conditions: (1) to look for plant type with determinate growth habit vis-a-vis synchronized flowering (2) development of shatter proof genotypes and (3) resistance to biotic stresses like Anagasta infestation, phylody, Macrophomina induced charcoal rot and Fusarium wilt to minimize yield loss.

To identify superior genotypes through diversity analysis, the present group were successful characterizing seventy one accessions of sesame (thirty one from Indian and forty from international repositories) keeping in consideration its origin and diversity centre. On the basis of statistical analysis of thirty phenotypic qualitative and quantitative traits, an algorithm based percent similarity value was derived for each sesame accession in comparison to a postulated ‘target sesame’. This approach led to short listing of certain accessions above ‘cut off values’, which can be utilized in different breeding programmes [1].

Deciphering suitable polymorphic marker(s), phenomic or genomic, is a prerequisite along with identification of parents for Marker Assisted Breeding (MAB). The present study aims to further characterize the short listed sesame accessions as stated earlier to look for both the aforesaid markers. The genomic markers in form of RAPD (Randomly Amplified Polymorphic DNA), SCAR (Sequence Characterized Amplified Region) and SSR (Short/Simple Sequence Repeat) are considered along with certain phenomic markers to discriminate between accessions and to select potential parents for marker assisted breeding programme of sesame.

Materials and methods

Sesame accessions

Of the seventy-one sesame germplasm studied were collected from national and international repositories on the basis of thirty morphological traits as stated

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