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R Sangeetha Vishnuprabha
Ph.D. Scholar, Department of
Genetics and Plant Breeding,
Tamil Nadu Agricultural
University, Tamil Nadu, India

Early maturity: A key to climate resilience

R Sangeetha Vishnuprabha

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Abstract

The objectives in a Plant Breeding programme are subjected to continuous progression as and when the tastes and preferences of the mankind changes. Crop yield may be considered as one of the standard objectives on which there is no compromise. One other objective that is gaining energy nowadays among the farming community is early maturity in almost all the crop varieties. With its crucial role in the Climate resilience early maturity is gaining momentum as a prime objective in all the Plant Breeding programs. The various other quantitative traits that contribute towards the short duration of a crop include early days to first flowering, days to 50% flowering, high above ground biomass and quick source to sink transport. With its positive correlation to grain yield early maturity also pose difficulty in breeding for its improvement. The breeding studies for developing early maturing varieties of various crops are reviewed here. Despite several obstruction in breeding for short duration, the trait has taken an inevitable position in Climate resilient crop development.

Keywords: Early maturity, climate resilience, days to flowering, positive correlation, grain yield

Introduction

Primarily driven by human activities that increase greenhouse gas emissions especially from burning fossil fuels, there occurs the Climate change. Climate change leads to temperature hikes, shift in precipitation patterns and extreme weather that eventually risks the food security by adversely affecting crop yields, livestock productivity and the stability of food systems. One of the foremost challenges faced by crop researchers today is developing climate-resilient crop varieties.

Developing homeostatic phenotype of plants allow them to adjust its growth and development in response to varying climatic conditions. Climate change has led researchers to take up breeding for reduced damage to crops by flood, drought and salinity.

Stability of genotypes across different environment and varying climate within an environment is a key for climate resilience. In the areas of short growing seasons due to climate change early maturing varieties complete their life cycle within the period before the commencement of the adverse conditions. (Gratani, 2014)^[8].

Thus, one of the best approaches to combat climate change is to use short duration varieties of almost all the food crops. (Campbell *et al.* 2016)^[5]. As such, the farmers have shifted to the cultivation of early maturing varieties due the prevailing unpredictable onset and termination of rains (Armah *et al.* 2010)^[3]. Early maturing varieties are the climate smart cultivars as they possess the ability to escape the late season drought, pest and disease damages. (Singh, 1997)^[20] Earliness in maturity has a list of advantages that include:

- Reduction in the duration of crop risk
- Greater flexibility in sowing time within growing seasons
- Promotion of irrigation water conservation with reduced irrigation expenses.
- Suitable for drought prone areas
- better for intercropping systems
- escape late season diseases and insect pests

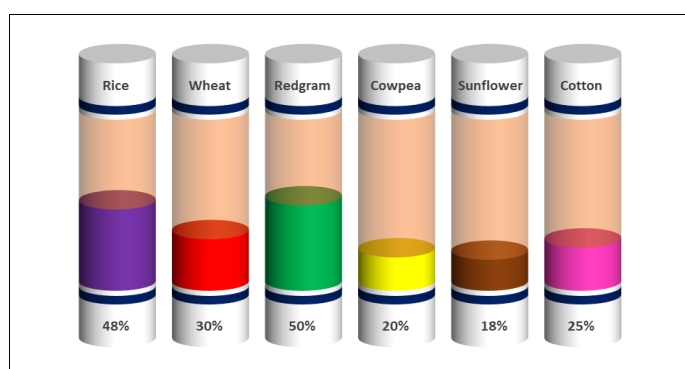
Alongside there comes also the complications in breeding for early maturity. Some of them include:

Corresponding Author:
R Sangeetha Vishnuprabha
Ph.D. Scholar, Department of
Genetics and Plant Breeding,
Tamil Nadu Agricultural
University, Tamil Nadu, India

- Short duration in most cases is positively correlated to yield: longer the duration higher is the yield of the crop. Reduction in crop duration reduces the yield. (Table. 1 and Figure.1)
- Lack of natural variation for early maturity trait in crops gene pool.
- The trait is highly influenced by the environmental factors.

Table 1: Genotypic correlation of Days to maturity to Crop yield

S. No.	Crop	Correlation of Days to maturity with Yield	Author
1.	Rice	0.4752**	Patel <i>et al.</i> 2025 ^[15]
2.	Wheat	0.301*	Sumit <i>et al.</i> 2025 ^[25]
3.	Redgram	0.499	Chandana <i>et al.</i> 2025 ^[6]
4.	Cowpea	0.195	Wadghane <i>et al.</i> 2025 ^[28]
5.	Sunflower	0.181	Hilli <i>et al.</i> 2021 ^[9]
6.	Cotton	0.2524**	Sirisha <i>et al.</i> 2016 ^[22]

**Fig 1:** The correlation% of the crops with grain yield.

In this paper, the studies related to the development of early maturity along with yield in various crops are discussed.

Rice

High yield and short duration rice genotypes are very useful in making the rice production more profitable, especially in the areas of unpredictable climate. In a study at Indonesia, the early maturity head date Hd gene from Nipponbare was transferred to Code rice variety. This line was released as a lowland variety in 2002. The line was developed from a well-known popular variety and hence effortlessly adopted by farmer and consumers. The study concluded that heading date is a crucial trait that determined majorly the duration of the crop. (Toenniessen 2003; Jena and Mackill 2008) ^[27, 10].

Singh, 2014 ^[21], have reported the importance of GCA effects in a combining ability cross to yield contributing traits viz., grain yield per plant, panicle initiation, days to 50% flowering, days to maturity, effective tiller per plant and spikelet fertility. The lines in the analysis included Anjali, Shanthi and Vandana and MTU 7029 and BPT 5204 were the testers. The genotypes generated could be used as potential donors for the improvement of both yield and early maturity.

Wheat

The development of new breeding approaches has led to the evaluation of germplasm from diverse location around South Asia. The stress tolerant wheat germplasm from CIMMYT has been directly released as variety or been used in global breeding programs.

Mondal *et al.* 2016 ^[13], reported the study of characterisation wheat germplasm in CIMMYT for climate resilience. The wheat

early maturing germplasm lines of Cd. Obregon, Mexico were evaluated in five differing environments. The traits Days to heading and grain yield were significantly associated in negative direction and also the association of both with temperature stress was the same. The results of the study demonstrate that short duration, high yielding, heat tolerant wheat lines were high in adaptability. The lines were successfully adopted by the farmers of South Asia with the key attractive trait early maturity to be used in rotation with other crops.

Redgram

The super early redgram genotypes mature in 90-100 days and have paved way to explore their cultivation in non-traditional areas leading to the increase in the national production. These short duration varieties also possess other important traits viz., synchronised maturity, hardiness, photo insensitivity and adaptability to multiple cropping systems (Saxena *et al.* 2019) ^[19]. Srivastava *et al.* 2012 ^[24], reported that the pigeonpea germplasm own a vast genetic variability for days to flowering and days to maturity (85-270 days). The super early group of redgram studied was 'ICPL 88039' and comes to flowering 3-5 days ahead of non-determinates and produced high biomass.

With the study of flowering and hybridization of wild relatives of pigeonpea identified *Cajanus platycarpus* as the only early maturing accessions (Remanandan *et al.* 1988) ^[18]. To breed for wider adaptable pigeonpea beyond 35° latitudes is possible only with photo-insensitive cultivars which are directly related to early to super early maturity (Wallis *et al.* 1981) ^[29].

Acknowledging the importance of early maturity, All India Co-ordinated Pulses Improvement Project (AICPIP) jointly by ICAR and ICRISAT have released a number of short duration pigeonpea varieties in India. Some of the successful short duration varieties developed in India include T₁, CO1, CO2, CO4, Prabhat, Pusa 855, Pusa 992, and that of hybrids include ICPH 2429, UPAS 120, ICPH 2438 etc.

Cowpea

The production of cowpea yield is constrained by several abiotic and biotic stresses. The trait short maturity period comprises an important adaptation in a wide range of agroecological zones with special reference to arid and semiarid tropics. In these areas the crop matures within 55-65 days (Abadassi, 2015) ^[1].

The reduced crop cycle of the crop also helps in overcoming the incidence of pests and diseases, terminal drought and unfavourable temperatures. The landraces that serve as a potential source for early maturity includes *Sanzi* and *Sumbirizie* (Song, 2013) ^[23].

Owusu *et al.* 2018 ^[14], studied the generations of the cross involving the landrace *Sanzi* that is extra early in maturing and medium maturing variety *Padi-Tuy*. The authors have reported highly significant genetic variations for different maturity indices viz., days to first flowering, days to 50% flowering, days to pod maturity with first pod and 90% pod. Also, they have studied the reciprocal cross generation that showed no significant variation indicating the absence of maternal effects in maturity characters. The study also confirmed positive association of the maturity indices with the grain yield indicating longer duration crops yield more. They have suggested selection of early maturity alongside grain yield.

Adeyanju and Ishiyaku, 2007 ^[2] claimed the resistance of the extra early cowpea varieties to striga in a study of genetics of earliness in cowpea. However, when it comes for dual purpose cowpea Ewansiha *et al.* (2018) ^[7] found that it may be difficult for combining early maturity characteristic with high grain and

fodder yield together. Kamai *et al.* (2014)^[11] reported significant negative correlation of grain and fodder yield in all the selected early maturing cowpea genotypes.

Sunflower

The modern sunflower hybrids are medium late to medium early with negative associations between seed and oil yield and maturity (Kaya *et al.* 2004)^[12].

Late maturing hybrids of sunflower with full vegetation possessed high seed yield compared to the medium-early to early maturing hybrids. The tendency of reduction in the yield with the reduction in maturity duration drifted the breeding of medium early sunflower hybrid with high yield in different areas of Serbia (Balalić *et al.* 2012)^[4].

Though the early maturing sunflower hybrids exhibited low genetic yield potential, showed favourable values for stability parameters across different environment as reported by Taran *et al.* (2014)^[26].

Cotton

Most cotton breeding programs take up earliness of yield development as a foremost objective. In case of cotton, early maturity is the outcome of determinate fruiting cycle.

In addition to this number of nodes of first fruiting branch can be operated for earliness of yield development (Ray and Richmond, 1966)^[17]. As reported by Zihong and Jun (2001)^[31], rates of blooming and vertical and horizontal flowering intervals could also be used as the estimators of earliness in cotton.

Wells and Meredith, 1984^[30], suggested that the ability of the crop to fulfil the resources to the fruit, modulates the rate of site production and rate of shedding that together contribute to the crop maturity. Eventually, the study of Quisenberry and Roark, 1976^[16] indicating the trade-off between early maturity and yield potential in cotton stands true in most cases.

The various traits contributing to early maturity in the reviewed crops are summarised in Table.2.

Table 2: Traits contributing early maturity in crops

S. No.	Crop	Traits contributing Early maturity
1.	Rice	Days to 50% flowering, days to maturity, effective tiller per plant, spikelet fertility
2.	Wheat	Days to heading
3.	Redgram	Days to flowering, determinate type
4.	Cowpea	Days to first flowering, days to 50% flowering, days to pod maturity with first pod and 90% pod
5.	Sunflower	Days to flowering
6.	Cotton	Number of nodes of first fruiting branch, rates of blooming, vertical and horizontal flowering intervals

Conclusion

Recognizing the critical role of early maturity in enhancing climate resilience, it has become an indispensable objective across nearly all modern crop breeding programs. The positive correlation exhibited by the trait with the yield, its limited sources in the gene pool and low genetic gain when selected pose challenges to the breeders in the development of the trait. Ultimately, it demands flexible breeding strategies and long-term investment in research. The modern-day plant breeding tools and techniques viz., Marker assisted selection, Genomic Selection, CRISPR-Cas9 gene editing, have been immensely being used in the breeding programs of climate resilience. By the combined approach of scientific advancements and the farmer-centric approaches, favourable genetic progressions in the traits for climate resilient have been successfully achieved including the early maturity trait.

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