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Prevalence and Variation of Viviparous Germination in *Tagetes erecta* L. (Asteraceae) in Island's Ecosystem

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ABSTRACT: *Tagetes erecta* L. is the most important and versatile commercial flowering plant and belongs to the family Asteraceae. The germination of viviparous seeds occurs while they are still attached to the mother plant (precocious germination), a relatively unusual phenomenon in angiosperms. True vivipary is reported mostly in mangroves and is a very rare phenomenon in Asteraceae. This vivipary is advantageous by disseminating offspring in time and space by which it evolved as a mechanism to provide a more efficient germination and survival means. In this study, we present the first observation of the rare phenomenon of 'vivipary' in local marigold accessions at Island ecosystem. The results of the study showed that the range and mean value of number of viviparous seedlings capitutlam^{-1}, number of non-germinated and total seeds capitutlam^{-1} varied from (31.0 to 84 and 58.3), (52.0 to 167.0 and 113.9) and (118.0 to 230.0 and 172.2), respectively. In case of % viviparous germination, it ranged from 19.3 to 56.7 with mean value of 35.9. Viviparous germination was observed in disc florets of the capitulum and autochory of few viviparous seedlings were observed. The occurrence of this rare vivipary was observed during monsoon season and hence it may be believed that it is a physiological response to the environmental condition and also due to inherent genetic character as it was observed only in local accessions of marigold.

Keywords: Asteraceae, marigold, vivipary, Island.

INTRODUCTION

Vivipary is the precocious phenomenon found in flowering plants where seeds germinate within a closed fruit and continue its development into a seedling still attached to the parent plant (Goebel, 1905, Carey, 1934, Elmqvist and Cox 1996, Farnsworth, 2000; Singh and Murugan 2013). Formation of a seed and growth of sexually generated embryo are integral to the viviparous process (Farnsworth, 2000) and is regulated by phytohormones that simultaneously control the responses of seedlings and mature plants to environmental changes, in addition to seed physiology (Farnsworth, 2004). Till date, vivipary has been documented in 195 plant species that include 78 families and 143 genera (Farnsworth, 2000). Occurrence of vivipary in flowering plants is a potential reproduction strategy rather than precocious germination process (Farnsworth 2000, Cota-Sanchez 2004) and also in island's ecosystem (Singh and Murugan 2013). Chauhan *et al*. (2018) reported from Uttarakhand (India) that it is a rare and unique reproductive mechanism in plants and may be a strategic resource for survival in the endangered *Saussurea lappa* (Decne.) Sch. Bip., an important medicinal and aromatic crop of Asteraceae family. The occurrence of vivipary in non-mangrove plant, *Hibiscus cannabinus* L. (Kenaf) of Malvaceae from Andaman and Nicobar Islands has been described for the first time by Singh and Murugan (2013). We here describe prevalence and variation of viviparous germination in marigold, *Tagetes erecta* L. from Andaman and Nicobar Islands, a well-known geographical region for its richest and unique plant diversity with high endemism in India (Singh *et al.* 2014; Singh *et al.* 2020).

Tagetes erecta L. is the most important and versatile commercial flowering plant belongs to the family, Asteraceae. This flower crop is even highly suitable to grow in aquaponic production system (Mohapatra *et al.*, 2021). Nationally, marigold is grown in large scale for commercial cultivation because of its mutil-faceted utilities (Sharma *et al.*, 2022). It is a most popular loose flower in Andaman and Nicobar Islands because of its year round demand, easy cultivation, wide adaptability and ability to withstand adverse climatic conditions like high rainfall and humidity. This Island has tropical humid equatorial climate with annual rainfall of 3200–3500 mm, 80–85% relative humidity and less diurnal variation. Due to cultural ethnic diversity, the consumption demand exists in throughout year for both loose and cut flowers in Islands. About 90% of the flower requirement is met by the import of flowers from mainland Indian states. Marigold holds major share among the loose flowers imported. It is cultivated

in the Islands about 37.23 ha area with production of 31.05 mt. Marigold varieties *viz.*, Siracole, Pusa Basanti Gainda, Pusa Narangi Gainda and other private sector hybrids grown on a small scale by Island farmers and is also grown in homestead gardens as well as an intercrop in plantation based cropping system.

MATERIALS AND METHODS

Exploration trips were made during 2018 for collection of marigold from across Andaman and Nicobar Islands. Nine accessions were collected from different areas of South Andaman and North & Middle Andaman districts and planted at Horticulture farm, ICAR-Central Island Agricultural Research Institute (ICAR-CIARI), Port Blair. They were evaluated from 2018 onwards for better flower yield. Arare phenomenon of precocious germination 'vivipary' was observed in few collected local accessions and the data on them were recorded in 10 samples for the traits *viz.,* number of viviparous seedlings capitulam^{-1}, length of seedlings/ radicles and number of roots seedling^{-1} including their survival under shade/ poly-house/ room temperature. Viviparous seedlings were separated from the capitulum planted in protrays (30 cells per tray) and were placed in different growing conditions like polyhouse, shade house and at room condition for assessing growth performance. Data were analysed for range of variation along with weather parameters for the period.

RESULTS AND DISCUSSION

Local marigold accessions with vigorous growth and prolonged flowering than popular introduced varieties were noticed during exploration trip across Islands. Among them, three best performing genotypes from South Andaman were identified after two years (2018–2020) of evaluation at Horticulture farm, ICAR-Central Island Agricultural Research Institute (ICAR-CIARI), Port Blair with characteristic flower colour as yellow, sulphur yellow and orange one along with more flower yield. It can be highly amenable for year round cultivation through vegetative propagation to maintain the true-to-type of parental genotype. While marigold evaluation at farm, 'vivipary' a rare phenomenon of precocious germination was observed only in selected local accessions during late monsoon months of August to October when flowers have already matured well (Fig. 1). However, viviparous germination was also noticed at flowering well before petal drying. Data on number of viviparous seedlings capitulam^{-1} and their survival under shade/ poly-house/ room temperature, length of seedlings/ radicals and number of roots seedling^{-1} were taken in ten samples and are presented in Table 1.

Range and mean value of number of viviparous seedlings capitutlam^{-1}, number of non-germinated and total seeds capitutlam^{-1} varied from (31.0 to 84 and 58.3), (52.0 to 167.0 and 113.9) and (118.0 to 230.0 and 172.2), respectively. In case of % viviparous germination, it was ranged from 19.3 to 56.7 with mean value of 35.9 under present study. Length of seedlings (cm) and radicles (cm) varied from 6 to 1.6 and 0.5 to 1.0 with mean value of 1.0 and 0.7, respectively. Seed vigour index varied from 16.6 to 48.8 with mean value of 35.0.

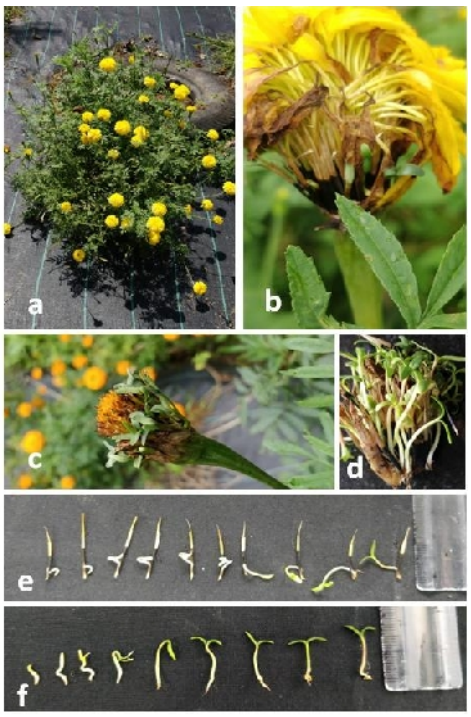

Fig. 1. Vivipary in local accessions of Marigold at ICAR-CIARL, Port Blair, Andaman and Nicobar Islandsa) A normal plant with flowering, b) Head with viviparous germination at field in Yellow coloured local accession c) Head with viviparous germination at field in Sulphur yellow coloured local accession, d) Cross section of Head with viviparous germination, e and f) Variation in viviparous germination within single Head.

Number of roots seedling^{-1} varied from 0.0 to 3.0 with mean value of 0.8. Mean survival of these viviparous seedlings (%) under different conditions *viz*., shade, poly-house and room condition were observed as 27.4, 62.0 and 3.9, respectively. Comparatively, the mean survival of viviparous seedlings (%) of marigold was better in poly-house condition than under shade condition with least at room condition. Occurrence of vivipary in several members of Asteraceae family reported as follows: *Abrotanella linearis* Berggr. (Burrows 1994); *Acamptopappus* (A. Gray) A. Gray. (Young and Young 1992); *Ageratina adenophora* (Spreng.) R.M. King & H. Rob. (Karmakar and Hazra 2016); *Eclipta alba* (L.) Hassk. (Bimal *et al.* 2014); *Pachystegia Chessman* (Burrows 1994); *S. lappa* (Decne.) Sch. Bip. (Chauhan *et al.*, 2018); *Senecio johnstonii* Oliv. subsp. *Johnstonii* (Leck and Outred 2008); *Tagetes erecta* L. (Anand and Mathur 2012); *Taraxacum officinale* L. (Lyman and Ellstrand 1984). Its occurrence in marigold was first reported in Rajouri district of Jammu and Kashmir in India where the seeds inside inflorescence 'head' begin to germinate due to over wetness of head by heavy rainfall during June-August, 2012 (Anand and Mathur 2012). As assumed

by earlier workers (Anand and Mathur 2012, Majumdar *et al.,* 2004), we are also presuming that the occurrence of vivipary may be involved by both intrinsic and extrinsic factors namely physiology, soil conditions, temperature and dry spells followed by high humidity induced by heavy rainfall. It was evidenced from Island's weather condition in 2018–2020 that the heavy rainfall along with high relative humidity during June to till August as heavy rainfall in June (645.7mm) followed by dry spells in July (238.1mm), then again heavy rainfall in August (674.8mm) with consistent relative humidity as 84.7 to 87.0% (Fig. 2). Vivipary favoured by excessive atmospheric moisture has also been reported in *S. lappa*(Chauhan*et al.* 2018), *Trifolium repens* L. (Fabaceae) (Deore and Johnson 2008), *Jatropha curcas* L. (Euphorbiaceae) (Majumdar *et al.* 2004), and various cacti (Cota-Sanchez *et al.* 2011).

Table 1: Different parameters observed on vivipary in local accessions of Marigold grown in Andaman and Nicobar Islands.

Particulars	Samples										Mean	Min	Max
	1	2	3	4	5	6	7	8	9	10			
VS*	84.0	68.0	64.0	83.0	57.0	45.0	46.0	52.0	53.0	31.0	**58.3**	**31.0**	**84.0**
NGS	72.0	52.0	54.0	147.0	144.0	78.0	157.0	167.0	138.0	130.0	**113.9**	**52.0**	**167.0**
TS	156.0	120.0	118.0	230.0	201.0	123.0	203.0	219.0	191.0	161.0	**172.2**	**118.0**	**230.0**
%VG	53.8	56.7	54.2	36.1	28.4	36.6	22.7	23.7	27.7	19.3	**35.9**	**19.3**	**56.7**
LP (cm)	0.6	0.8	0.9	1.1	1.6	1.3	1.0	0.7	0.9	1.4	**1.0**	**0.6**	**1.6**
LR (cm)	0.6	0.6	1.0	0.6	0.5	0.9	0.6	0.6	1.0	0.8	**0.7**	**0.5**	**1.0**
SVI	32.3	45.3	48.8	39.7	45.4	47.6	22.7	16.6	25	27	**35.0**	**16.6**	**48.8**
RS	0.0	0.0	0.0	0.0	3.0	1.0	1.0	0.0	1.0	2.0	**0.8**	**0.0**	**3.0**
Survivability of viviparous seedlings (%)													
Shade	18.5	23.2	31.6	25.2	33.0	19.5	21.4	40.2	32.6	28.4	**27.4**	**18.5**	**40.2**
Poly-house	63.2	71.5	58.4	81.2	67.1	70.3	60.2	55.8	43.2	49.5	**62.0**	**43.2**	**81.2**
Room	7.6	6.5	3.2	4.5	1.6	2.8	3.0	2.5	5.1	2.0	**3.9**	**1.6**	**7.6**

*__VS__-Number of viviparous seedlings Capitutlam^{-1}; **NGS**-Number of non-germinated seeds Capitutlam^{-1}; **TS**- Total number of seeds Capitutlam^{-1}; **%VG**- Percent of viviparaous germination Capitutlam^{-1}; **LP**- Length of plumule; **LR**- Length of radicle; **SVI**- Seed vigour index; **RS**- Number of roots Seedlings^{-1}.

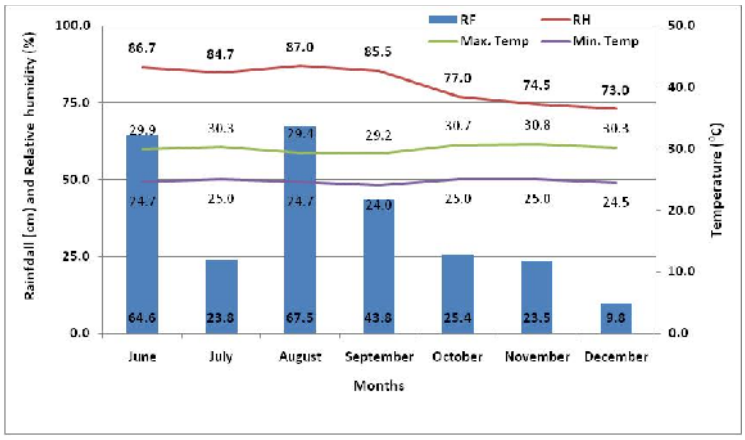

Fig. 2. Weather parameters during the Vivipary observation in marigold at Port Blair, Andaman and Nicobar Islands (Monthly average of three years from 2018 to August, 2020) Source: Directorate of Economics and Statistics, Andaman and Nicobar Administration (http://andssw1.and.nic.in/ecostat/2020/totalrainfall.pdf).

Though excessive atmospheric moisture and wet condition resulted in premature germination or viviparous germination of seeds in many crops, it also involves the intrinsic factors including genetic characteristics of the genotype could play a main role in determining them. Vivipary has also been induced in maize by application of fluridone which reduced abscicic acid (ABA) levels during seed maturation (Oishi and Bewley 1990). It is an undesirable phenomenon in cereal crops because pre-harvest sprouting leads to low yields and have significant consequences in the agricultural industry and plant conservation (Kermode 2005, Cota-Sanchez 2017). It is also reported as an adverse condition in several crops like coconut (Sankaran *et al.,* 2012), tomato (Cota-Sanchez, 2017), corn (Neill *et al.,* 1987), apple (Mani, 1947) as it affects fruit taste and quality.

Vivipary can also be treated as a specialized trait of evolutionary and biological significance as it provides new avenue or advanced feature for survival and also as a mechanism for protecting the embryos from abiotic stress conditions especially drought (Cota-Sanchez 2004; Majumdar *et al.,* 2004; Deore and Johnson 2008). This implies that the viviparous trait confers fitness advantages by disseminating off spring in time and space in new areas of the host plant and other ground substrates, which is in agreement with Cota-Sanchez *et al.* (2007), who suggested that vivipary evolved as a mechanism to provide a more efficient germination and survival means while contributing to population

maintenance and short-distance dispersal. The extraordinary adaptability of seeds to germinate in diverse environments is a good indicator for the commercial propagation of crop (Sharma *et al.,* 2006). It is an intrinsic reproductive mechanism favouring the germination and dispersal of the fittest offspring regardless of substrate and environmental conditions. In general, the presence of pappus (persistent modified calyx) in Asteraceae family helps the cypsela (fruit type) to migrate over different places and also maintain its dispersal once the flower gets maturity.

Vivipary in marigold (member of superior family Asteraceae in Angiosperms with diverse species), can be viewed as a new mode of reproduction strategy.

CONCLUSION

It can be concluded that vivipary is a trait of evolutionary, physiological and biological significance and its occurrence in different members of Asteraceae may be studied. This viviparous trait confers fitness advantages by disseminating offspring in time and space by which it evolved as a mechanism to provide a more efficient germination and survival means. Its better survival observed under poly-house study could provide an opportunity for more multiplication of the species which has to be studied in detail.

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Conflict of Interest. None.

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