Review of literature

The family Amaryllidaceae is now contained 85 genera among them the genus *Crinum* L. has 1300 species around the world (Willis 1973, Raven & Axelrod 1974, Nordal 1977, Meerow et al. 2003, Govaerts et al. 2012). The name *Crinum* is derived from the Greek krinon, which means white lily (Verdoorn 1961). Linnaeus established the group *Crinum* in 1737 recognizing with four species, *Crinum latifolium, C. asiaticum, C. americanum* and *C. africanum* (Nordal 1977).

Most of the species of the genus are found in different habitat like seasonal moist areas, marsh and swamps land as well as beside the lake in tropical and sub-tropical areas in worldwide (Kwembeya and Stedje 2007, Kwembeya et al. 2007, Lekhak and Yadav 2012). A few taxa are commonly told as pan species (Bjora et al. 2006), have developed adaptations to grow in occasionally flooded pans, in clay and loam soils. The term Geophytes is first proposed by Raunkiaer in 1934. Geophytes are the plants with underground perennial organs like bulbs, corms, tubers or rhizomes. The Southern Africa is supposed to be the centre of origin for this pantropical genus (Meerow and Snijman 1998, Meerow et al. 2003, Sebsebe et al. 2003, Kwembeya et al. 2007).

Karthikeyan et al. in 1989 are specified the genus 12 species, 6 varieties and 4 forms from India. Ansari and Nair (1988) merged *C. defixum* Ker Gawl. and *C. defixum* var. ensifolium (Roxb. ex Ker Gawl.) Baker into *C. viviparum* (Lam.) R. Ansari & V. J. Nair. Recently a new species has been added in India - *C. malabaricum* Lekhak and S. R. Yadav from Kerala (Lekhak and Yadav 2012). Hence, the total number of species of the genus for India rises to 13, of which 8 species belong to subgenus Platyaster or Codonocrinum (having funnel-shaped perianth) and 5 species are subgen. Stenaster (having star-shaped perianth). Out of

five Stenaster species: *C. asiaticum*, *C. lorifolium*, *C. malabaricum* and *C. viviparum* var. *viviparum* occur in Peninsular India whereas *C. wattii* Baker is known from Assam and Thailand, which has small 2 inch diameter bulbs, a 6 – 8 flowered umbel and linear perianth segments (Bajora et al. 2009). In Peninsular India, only species *C. asiaticum* is usually grown in the gardens (Tram 2002, Bajora et al. 2009). The species has linear perianth segments. Very recently in this year, another new species has been recorded by Patil and Patil (2019) from Gujarat by name *Crinum reddyi* sp. nov.

Different species and provenance are shown morphological, phonological and anatomical variation among them (Snijman and Linder 1996, Kwembeya and Stedje 2007). Now a day, due to attractive floral diversity, some of the species are being used in different gardens (Olorode 1984, Hannibal and Williams 1998, Tram et al. 2002, Patel et al. 2010). Bjora et al. 2006 is enumerated that the studied genus shows different diversity related to morphological appearance, fruit and seed morphology etc. *Crinum* has been divided into sections based on flowers appearance - star-shaped or bell-shaped (Herbert 1837, Baker 1898, Nordal and Fangan 1993). Meerow et al. (2003), supported by Kwembeya et al. (2007), recognized two clades with star-shaped flowers in the *Crinum* phylogeny, one clade including species from eastern parts of Africa, Madagascar, Asia and Australia, and the other including species from western Africa and America. Kwembeya et al. in 2007 expected that *C. natans* Baker would belong to the latter clade. Two types of seeds are reported in *Crinum* L. one type with a layer of cork that gives the seeds a high capacity for buoyancy (Koshimizu 1930, Hannibal 1966, Manasse 1990 and Bjora et al. 2006) and the other form is probably lacking

the cork layer, has non-buoyant seeds (Bjora et al. 2006, Nordal et al. 2010). Leaves in *Crinum* also include two forms (Snijman and Linder 1996). Evergreen leaves that have active photosynthesis continuously throughout the seasons and leaves that die back during seasonal drought (Snijman and Linder 1996). The last form is unique, combining the traits of being both deciduous and perennial. (Snijman 1999, Meerow and Snijman 2001, Meerow et al. 2003, Kwembeya et al. 2007).

The different species of *Crinum* L. have commercial, economical and medicinal importance (Shilpa et al. 2013). It is many claims in folklore it is used for treating analgesic, inflammations and wound healing activities (Nguyen et al. 2002, Shilpa et al. 2012, Shilpa et al. 2013). The *Crinum* plants have been used in different parts of the world to treat various disorders (Jagtap et al. 2014). The bulbs of C. *asiaticum* L. has been used in India as tonics, laxatives and expectorants and in urinary troubles (Patel et al. 2010, Refaat et al. 2012, Patel 2017).

The leaves and bulbs of different species of the genus are also used for nausea and vomiting, acidity and dysentery (Rahmatullah et al. 2010). The traditional people of Haryana, India are uses the bulb of the genus as a laxative and urinary troubles and for ear ache (Yadav and Bhandoria 2013). In Madhya Pradesh the tribals are used these plants as ear pain clear, wounds healing, indigestion and fever purposes (Choudhary et al. 2008, Kapale 2012, Haque et al. 2014).

The alkaloids of Amaryllidaceae have different chemical structures and are comprised of nine chief different types of chemicals, including lycorine, crinine, tazettine, montanine, belladine, lycorenine, galanthamine, cherylline and narciclasine (John et al. 2012). Amaryllidaceae have four sub- families – Agavoideae, Amaryllidoideae, Campynematoideae and Hypoxidoidae, but

alkaloids are only found in Amaryllidoidae (Hegnauer 1963). Alkaloids of Amaryllidaceae have been played an important role in taxonomic distribution (Waker and Nowaeki). Among the 130 species of *Crinum* L. only 35 have been recognized through the presence of alkaloids. Near about 180 types of alkaloids have been isolated and identified in this family (Lewis 1997, 2001, Refaat 2012). According to Refaat et al. 2002 claimed that forty types of lycorine like alkaloids have been isolated from the genus. Some uncommon alkaloids have also been reported from the family, such as – augustamine, β- carboline, phenanthridine, sceletium, ismine and clivimine (Refaat et al. 2012). The leaves extract of *Crinum asiaticum* L. is used as anticandidal potential (Surein and Anaya 2014). The leaf extract of *Crinum latifolium* L. have shown thrombolytic activity (Syed and Das 2013). On the basis of alkaloids chemotaxonomically separated three species of *Crinum* L. like *C. moorei, C.bulbispernum* and *C. malowanee* (Esameldin 2000). Among the different alkaloids group five most common groups are lycorine, homolycorine, tazettine, crinine and narciclasine alkaloids (Ghosal et al. 1983, 1988, Nair et al. 2000, Tram et al. 2002, Kim et al. 2006). One of the active component lycorine is used in multiple medical purposes, including anti-tumor, angiogenesis, anti-virus, anti-bacteria, anti-inflammation, inhibition of acetyl cholinesterase, anti-malaria, anti-leukemia and anti- cancer (Dewan and Das 2013, Jagatap et al. 2014, Miao et al. 2019).

The most important active principle - lycorine is a colorless crystal and melting point is 260 –262 °C and it is a stable compound and it can be preserved at room temperature for a few years (John et al. 2012). Previous works has been established that lycorine inhibited cell proliferation and induced cell apoptosis in acute

myeloid leukemia (AML) cell line HL-60 (Liu *et al.* 2004), it is also function on monocyte leukemia cell line and T-cell leukemia (Evidente et al. 2009). It is also blocked multiple myeloma KM3 cell cycle and induced K562 cell-cycle arrest at the G0/G1 phase (Li et al. 2007, Evidente et al. 2009, Li et al. 2012). The component also suppressed the growth of various tumor cells – melanoma, ovarian cancer cell, lung cancer and esophageal cancer cells (Lamoral et al. 2009, Liu et al. 2009, McNulty et al. 2009).

Lycorine of *Crinum* L. can blocks the viral RNA replication process and inhibit the protein synthesis pathway (He et al. 2013). It is also inhibits growth of several *Saccharomyces cerevisiae* (Vrijsen 1986). Lycorine is also preventing malarial activity against the pathogen *Plasmodium falciparum* (Cedron et al. 2010).

Cytological studies in different *Crinum* species are mainly restricted to somatic counts. Study of meiosis is very difficult, as it takes place in very young flower buds of underground bulbs as a result; it is inaccessible and relatively complicated to study (Lekhak and Yadav 2011). Chromosomes are fairly large and different basic chromosome number can enhance the interest of karyotype analysis of different species of the genus (Bose 1965, Jones and Smith 1967, Khoshoo and Raina 1968). Majority of the earlier reports suggested that genus *Crinum* L. is fairly stable with the basic number x=11 with diploids (Inariyama 1937, Sato 1938, Gouws 1949, Dolcher 1950, Sharma and Ghosh 1954, Sharma and Bhattacharya 1956, Fernandes and Neves 1961, Bose 1965). However, Jones and Smith 1967 have reported that polyploidy and B-chromosomes are common in the genus. Presence of polyploidy also reported by Bose 1965 in this genus. Suggested a new basic number x=12 as a derivation from x=11 by Jones and Smith 1967. However,

exceptional cases of 2n= 24 in *C. ornatum* and 2n= 20 in *C. distichurn* Herb. are reported to have the basic numbers x= 12 and x= 10 respectively, instead of the predominating basic number x= 11 (John and Smith 1967, Kammacher and Akei Assi 1975). Though, all Indian *Crinum* species are shown basic chromosome number x=11. The details karyotype study of two species *Crinum brachynema* and *C. woodrowii* from Northern Western Ghats of India showed same basic chromosome number (Lekhak and Yadav 2011). Some of the species have shown heteromorphism reported by Lekhak and Yadav 2011, Patwary and Zaman 1981. Previous chromosome studies have revealed that different *Crinum* species may occur with the chromosome numbers 2n= 22, 33 and 44 (Raina and Khoshoo 1971). Ahmed et al. 2004 have found 33 chromosome in mitotic metaphase of *Crinum latifolium*, whether others are reported 2n= 22 in the same species (Raina and Khoshoo 1971, Lakshmi 1980, Nwankiti 1985, Akhter *et al.* 1992, Dolai and Nandi 2020). In case of *Crinum asiaticum* is also shows 2n=22 chromosome (Sharma and Ghosh 1954, Raina and Khoshoo 1971, Patwary and Zaman 1975, Zaman *et al.* 1977). Ahmed et al. 2004 have been reported that *C. latifolium* is may be a allotriploid or a segmental triploid.

Fluorescent Chromosome Banding is being reported on three species of *Crinum* L. by Ahmed et al. 2004. The karyotypes were analyzed in populations of *Crinum zeylanicum* (L.) L. (2n= 22 and 30). *C. macowanii* Bak. (2n=22), *C. jagus* (Thomps.) Dandy (2n=22). *C. glaucum* A. Chev. (2n= 22). *C. purpurascens* Herb. (2n= 22) and *C. natans* Bak. (2n= 22) from tropical Africa. On the basis of chromosome morphology a karyotype evolution path of African *Crinum* spp. have been sketched by Walstrom and Laane 1979.

Meiosis studies of some species are recorded by the earlier workers (Darlington 1958, Walstrom and Laane 1979).

Phylogenetic relationship of seventy one species of this genus has been carried out by Kwembeya et al. in 2007 and found four different clades on the basis of total plant DNA analysis. Another species *Crinum woodrowii* is shown close relation with *Amaryllis belladonna* after investigation of plastidial DNA analysis (Jagatap 2015). Total genomic DNA analysis of different species of the genus from different geographical location indicating the relation among them and divided into different clades (Meerow et al. 2003). Morphological variation of seven species of *Crinum* supported by chroloplastidial DNA analysis (Fangan and Nordal 1993).

To develop an alternative conventional method of vegetative propagation Fennel in 2013 established propagation methods through micro propagation. Some earlier workers also developed so many methods in tissue culture like somatic embryogenesis, callus culture, micropopagation (Slabber et al. 1993, Mujib et al. 1996, Fennel et al. 2001, Fennel 2013, Silvana and Alberdan 2014). No other report on this field is found for this genus.

A few earlier reports have been found on pharmacognostic study of leaf of *Crinum asiaticum* and *Crinum latifolium* (Solanki et al. 2011, Vishnu Priya and Rao 2017).