

FLOWER MORPHOLOGY AND REPRODUCTIVE BIOLOGY IN DIFFERENT SPECIES OF GRAIN AMARANTHUS

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DOI : <https://www.doi.org/10.56726/IRJMETS32773>

ABSTRACT

The study on flower morphology of four species viz. *A. edulis*, *A. hypochondriacus*, *A. cruentus* and *A. caduatus* revealed that the flowers were monoecious compound, pentamerous with circumscissile utricles. The flowers are arranged in glomerules each with an initial staminate flower and indefinite of pistillate flowers. Glomerules are crowded on axes which make up the spikes of the inflorescences. Each flower is subtended by bract with a sharp point. The perianths of the flowers are made up of five free tepals, male flowers have five stamens and female being a utricle. The one male flower and six female flowers are arranged in each cluster. The reproductive biology revealed that the number of flowers per inflorescences was species wise different. The species to species variation was observed. *A. hypochondriacus* L. had highest number flowers per inflorescences and lowest number of flowers per inflorescence on the species of *A. edulis* L.

Key words: Grain Amaranthus, Flower Morphology, Inflorescences And Reproductive Biology

I. INTRODUCTION

Chenopodium spp. and Amaranth: *Amaranthus* spp.), grain amaranth is most important. Grain amaranthus (*Amaranthus* spp.) is traditionally an important edible pseudocereals, which is widely grown in Himalayas and also in the plains to some extent during rainy and cool season of the year.

The family Amaranthaceae (Dicotyledons, order: Caryophyllales) is composed of 60 genera and about 800 species. Many researchers viz., Candolle (1883); Ames (1939); Vavilov (1950); Hooker (1885); Merrill (1950) believed that grain amaranthus have been cultivated in Southern Asia from time immemorial and probably originated there. The genus amaranth is dibasic with $X=16$ and $X=17$ chromosome, almost equally distributed in section Amaranth. Grant (1959) has reported the information regarding the chromosome number of 30 species of *Amaranthus*. Among these, four have $2n=32$, while all others have $2n=34$. Among the 30 species, *A. caudatus* L. ($2n=32$), *A. cruentus* L. ($2n=34$) and *A. hypochondriacus* L. ($2n=32$) are domesticated species and among these three species *A. caudatus* L. is drooping type and rest two are erect type species. Three main amaranth species are grown for grain purpose. *A. caudatus* is early maturing species having 60 to 70 days require for maturity. This species is mostly grown in Kenya. The maturity depends on altitude; amaranth grain matures faster at lower altitudes. Usually, *A. caudatus* matures within 60 to 70 days in Africa. Due to early maturity, this species is favourable for the areas that have a short rainy season. *A. cruentus* is a medium duration species having 60 to 120 maturity days. It is often grown in Mexico and is least sensitive to photoperiod (hours of sunlight each day). *A. hypochondriacus* is long duration species having 150 maturity days. It is high yielding and disease tolerant species. There are three groups of food grains. The first group of food grains is cereals which include rice, maize, barley etc. The second group of food grains is millets, which include sorghum, pearl millet, finger millet, kodo millet etc. and third most important group of food grains comprising the grain amaranth (*Amaranth* spp.), buckwheat (*Fagopyrum* Spp.) and Chenopods

(*Chenopodium* spp.) belonging to three different families viz., Amaranthaceae, Polygonaceae and Chenopodiaceae, respectively.

Morphology studies in different species

The *Amaranthus hybridus* species complex (Amaranthaceae) is a group of five species including the wide spread agricultural Pigweed *A. hybridus* L. (smooth pigweed), a South American endemic *A. quitensis* Kunth, and the three cultivated grain amaranths *A. hypochondriacus* L. from central Mexico, *A. cruentus* L. from southern Mexico and Guatemala, and *A. caudatus* L. from the northern and central Andes. Mosyakin and Robertson (1996) reported that all species of the hybridus complex are monoecious, having flowers with five sepals, lacking petals, subtended by a bract, and a circumscissile dehiscent utricle typical of the subgenus *Amaranthus*.

Hauptli and Jain (1984); Gupta and Gudu (1991); Transue *et al.* (1994); Kirkpatrick (1995); Chan and Sun (1997); Xu and Sun (2001); Mandal and Das (2002); Mallory *et al.* (2008); Jimenez *et al.* (2013); and Kietlinski *et al.* (2014) Several studies of genetic diversity have been performed with a primary goal of elucidating the origins of the grain amaranths and their relationship to each other. Despite these numerous studies of genetic diversity, classification in the hybridus species complex varies widely from a single species approach that lumps all five species into *A. hybridus* to recognition of five species (*A. hybridus*, *A. quitensis*, *A. hypochondriacus*, *A. cruentus*, and *A. caudatus*).

Reproductive biology

Sauer (1950) studied four grain amaranth species, viz. *A. leucocarpus* S. Wats., (*A. hypochondriacus* L), *A. cruentus* L., *Acaudatus* L. and *A. edulis* Spegazzini. The grain amaranths are monoecious species and they exhibit two types of arrangement of the staminate and pistillate flowers. These types are important because of their different breeding behaviour. In the first type, the first flower of each flower cluster is staminate and all the secondary ones are pistillate.

Number of flowers per inflorescence

Kauffman (1979) reported that each head of amaranth consists of hundreds of floret arranged in a panicle. Each floret consists of 3-6 flowers with one male flower surrounded by several female flowers.

II. MATERIAL AND METHODS

Experimental material consists of following diverse 19 genotypes obtained from ‘Center for Crop Improvement, S.D. Agricultural University, Sardarkrushinagar.

Table 1: List of Amaranthus Genotypes

Sr no	Genotypes	Sources	Sr. no	Genotypes	Sources
1	<i>A. edulis</i>	S. K. Nagar	11	GA-2	S. K. Nagar
2	IC-381195	NBPGR, New Delhi	12	GA-3	S. K. Nagar
3	IC-381135	NBPGR, New Delhi	13	PRA-1	Ranichauri, Uttarakhand
4	Deesa local	S. K. Nagar	14	PRA-2	Ranichauri, Uttarakhand
5	EC-519549	NBPGR, New Delhi	15	PRA-3	Ranichauri, Uttarakhand
6	IC-1733	NBPGR, New Delhi	16	PRA-4	Ranichauri, Uttarakhand
7	Annapurna	NBPGR, Shimla.	17	RMA-7	Mandor, Rajasthan
8	Durga	NBPGR, Shimla.	18	Suvarna	Banglore
9	BGA-2	Bhuvneshwar	19	VL-44	Almora
10	GA-1	S. K. Nagar			



1. *A. edulis*



2. IC-381195



3. IC-381135



4. Deesa local



5. EC-519549



6. IC-1733





Plate 1: Inflorescence of grain amaranthus genotypes

Flower morphology

The different species flowers structure of grain amaranthus male and female flowers were observed under light microscope.

Reproductive biology

Number of flowers were counted on inflorescence by counting of total spikelets per inflorescence. Number of glomerules were counted per spikelets. Numbers of male and females flowers were counted on glomerules.

Total no. of flowers/Inflorescence = (no. of male + female flowers) × (no. of glomerules/spiklets) × (no. of spiklets / inflorescence)

III. RESULTS AND DISCUSSION

Flower morphology

Study of Inflorescence

A set of 19 different genotypes of four species were observed during research experiments and studied the inflorescences (Plates 1).

The grain amaranth species belong to the section *Amaranthotypus* of the genus *Amaranthus* and are characterized by monoecious compound inflorescences and pentamerous flowers with circumscissile utricle. The basic units of the inflorescence are little dichasial cymes, usually called glomerules, each ordinarily consisting of an initial staminate flower and an indefinite number of female flowers. The glomerules are crowded on a leafless axis to form complex inflorescences, which are generally called spikes. In all the grain species, each flower is subtended by a sharp-pointed bract. The perianth consists of five free 'petals', the male flowers have five stamens, the female a single circumscissile utricle.

The main axis of the inflorescence is usually branched. The length and number of these branches and their angle with the main axis determines the shape of the inflorescence. Individual flower clusters develop along these axes in an alternate fashion. The first flower is terminal on the branch and at its base two branches develop the second and third flowers. Each of these flowers in turn is terminal and at its base developed the next two flowers. This process continues until all the available space is occupied. Development is usually very symmetrical up to the third or fourth series of flowers. At this time, the setting of the first seed usually slows down growth and upsets the symmetry. Unpollinated clusters may develop an exceptionally large number of flowers.

Grain amaranthus, exhibit two types of arrangement of the staminate and pistillate flowers. In the first type, the first flower of each flower cluster is staminate and all the secondary ones are pistillate.

Morphology studies in different species

Grain amaranthus have monoecious compound inflorescence. The flowers were pentamerous with circumscissile utricles. The flowers were arranged in glomerules each with an initial staminate flower and indefinite of pistillate flowers. Glomerules are crowded on axes which make up the spikes of the inflorescences. Each flower is subtended by bract with a sharp point. The perianths of the flowers are made up of five free petals, male flowers have five stamens and female being a utricle (plate 2).

The different four species of grain amaranthus was observed during experimental studies in light microscope.

A. *hypochondriacus* L.

The flowers were green, red, purple and dark red or maroon in colour. viz. GA-1, GA-2 and GA-3. Inflorescences enormous, of terminal and lateral panicles or spikes (80 cm). The bracts large, as long as style branches, long pointed giving the inflorescences a prickly look. The utricle is circumscissile with large cap. One male and six female flowers in each cluster which arranged like in center one male and six female flowers around it (plate 3-H)

A. *caudatus* L.

The flowers were green and red mix colors. Styles are spreading, inner tepals obtuse. The 5 petals were broad (plate 3- I). Inflorescence was indeterminate, the central inflorescence branch exceeds the side branches. Inflorescence usually of lax, extremely long drooping (70-75 cm.) spike or panicles.

A. *cruentus* L.

The flowers were green in colour. viz. Annapurna, PRA-1, PRA-2, PRA-3 and PRA-4 Inflorescence fully developed, lower inflorescence forming lax and soft spikes (70 cm). The bracts shorter than style. petals were 5 and straight. The morphological features are shown in (plate 3 -J).

A. *edulis* L.

The flowers were golden yellow in colour. The petals are smaller and less strongly recurved and the style branches are erect. The spikes become extraordinarily blunt and club-shape. The morphological structure is shown into plate (3 - K).

4.2. Reproductive biology

A data (Table 1) revealed that the number of flowers per inflorescence were differed in different species. The species to species variation were observed.

Table 1 Range of number of flowers per inflorescence

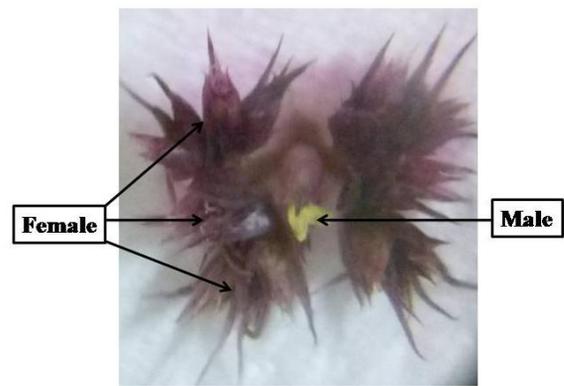
	Species	Range
1	<i>hypocondriacus</i> L.	4,88,000- 30,00,000
2	<i>cruentus</i> L.	5,00,000- 25,00,000
3	<i>caudatus</i> L.	1,68,000-10,00,000
4	<i>A. edulis</i> L.	56,000-1,98,000



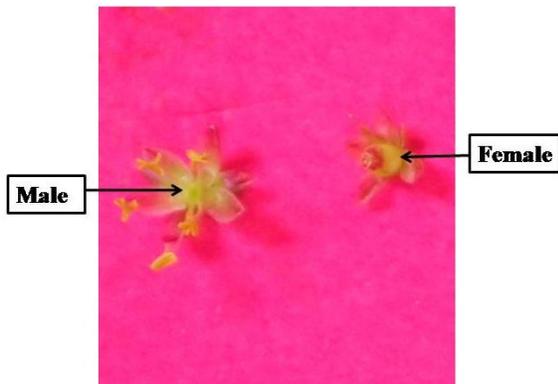
(A)



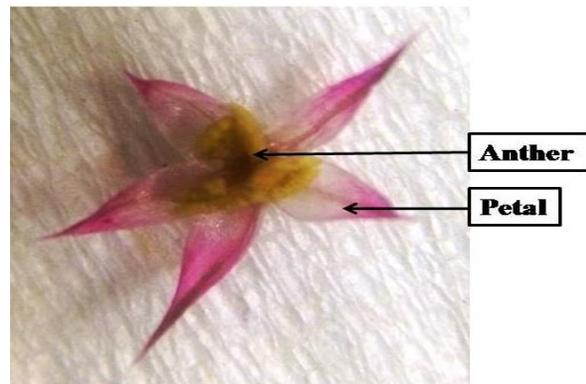
(B)



(C)



(D)



(E)



(F)



(G)

Plate 2: Flower morphology of grain amaranthus

Bracts; (B) Petals; (C)

(D) Male and female flowers; (E) Male flower; (F and G) Female flower



Male

Female

A. hypochondriacus

(H)



Male

Female

A. caudatus

(I)



Male

Female

A. cruentus

(J)

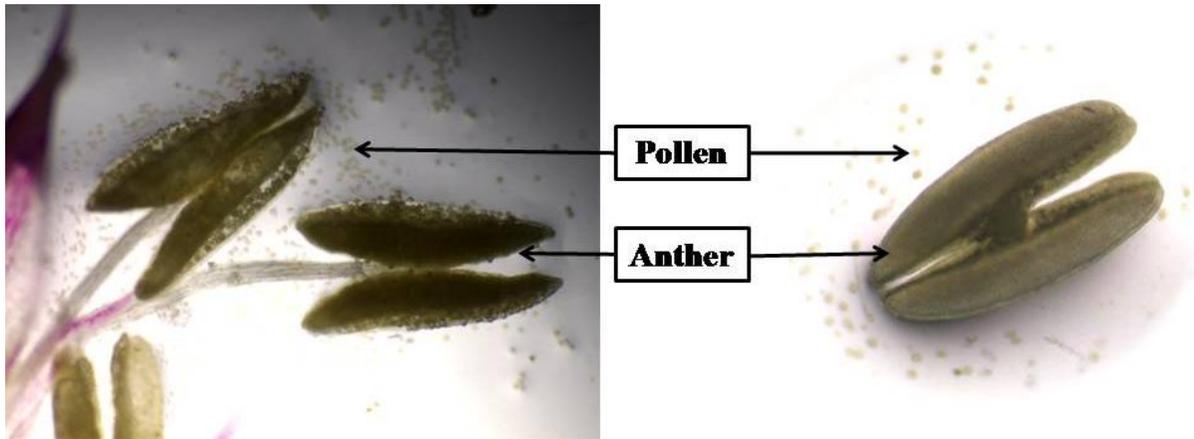


Male

Female

A. edulis

(K)



(L)

Plate 3: Flower morphology of grain amaranthus

(H to K) male and female flowers of different *Amaranthus* species;

(L) Anther

IV. CONCLUSION

The highest number of flowers per inflorescence was observed into *A. hypochondriacus* L.(4,88,000 - 30,00,000) total number of flowers per inflorescences and lowest number of flowers per inflorescence on the species of *A. edulis* L. (56,000-1,98,000).

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