Arab Gulf J. Scient. Res., **12** (3), pp.525 - 545(1994)

Perspectives on the Biology of *Heliotropium curassavicum* in the Deltaic Mediterranean Coast of Egypt

Ahmad K. Hegazy[1]*, Magda I. Soliman[2] and Ibrahim A. Mashaly[3]

[1]Department of Botany, Faculty of Science, University of Qatar, P.O. Box 2713, Doha, Qatar
[2]Faculty of Science, (Damietta Branch), University of Mansoura, and [3]Faculty of Science, University of Mansoura, Mansoura, Egypt

ABSTRACT. *Heliotropium curassavicum* L. (Boraginaceae) has become a serious polycarpic weed infesting many agricultural fields in the newly reclaimed salt affected lands in the Deltaic Mediterranean coast of Egypt. Floristic composition of its plant communities, seed germination, phytomass allocation, adventitious root buds, cell division and karyotype analysis, and pollen fertility were investigated. The following results were obtained: (1) The poor adaptation of its associated wild plants and the strong selection pressure in the Deltaic agro-ecosystems supported the dominance of *H. curassavicum* as a weed. (2) Persistence of intermittent seed germination and seedling establishment in open areas increases the chance of its spreading. (3) Synchronized pattern of dry phytomass allocation and phenological events through different stages of the life cycle. (4) Ability to produce adventitious root buds allow for the plant's perennation and wide spreading. (5) Chromosomal abnormalities during the cell division included lagging chromosomes, chromatin bridge, stickiness, mis-orientation and asynchrony. These abnormalities and the reduced pollen fertility made the species shifts its sexual reproduction to vegetative propagation by adventitious root buds.

Heliotropium curassavicum L. (Boraginaceae) has become one of the common polycarpic weeds infesting the newly reclaimed fields in the middle sector of the Deltaic Mediterranean coast of Egypt. Because of its vigorous growth and natural ability to colonize the disturbed salt affected sand flats, the species spreads rapidly invading the newly reclaimed lands and the surrounding fields as a troublesome weed.

* To whom correspondence should be sent.

Baker (1974) and Hill (1977) defined "weediness" as a group of characteristics possessed by a plant which tend to occupy habitats associated with weeds. Such habitats have often created wholly or partly by man. The characteristics which make *H. curassavicum* a weed are almost self-evident (cf. Grime 1979). As pointed out by Sen *et al.* (1980), successful weeds in any region of arid zones, usually have both seed and vegetative propagation at their disposal.

Previous investigations on *H. curassavicum* in other areas of the world were conducted at the taxonomic level (Miller 1988), on phytochemical screening (Subramanian *et al.* 1980, Catalfamo *et al.* 1982, Mohanraj *et al.* (1982), Davicino *et al.* (1988), with a few studies on physiological adaptations (Mooney 1980, Roy and Mooney 1982). sarker *et al.* (1973) and Frohlich (1980) reported chromosome numbers of n = 13 and pollen fertility of 29.87% for *H. curassavicum*. However, weed biology is a subject embracing many disciplines including ecology, physiology and genetics. Of the many studies on weeds, most were concentrated directly or indirectly on weed control. Meanwhile, introduction of weeds as a biological phenomenon is still an understudied area (Muzik 1970, Hill 1977). To the best of our knowledge at present there are no biological studies carried out on the species in Egypt.

The objectives of this study were to: (1) describe the soil chemical and physical properties and the floristic composition in the habitat of *H. curassavicum* (2) study the major factors affecting the seed germination and seedling establishment, (3) investigate the role of roots in vegetative propagation, (4) study the dry matter allocation and phenological changes at different growth stages, and (5) study the cell division and karyotype analysis.

Study Area

The study area is located in Ziaan county, about 5 km south of Gamasa sea-side resort (latitude 31° 30′ N, longitude 31° 65′ E). Detailed description of the area is found in Mashaly *et al.* (1993) and Mashaly (1987).

Materials and Methods

Soil and Vegetation Analyses

The procedures followed in the physical and chemical analysis of the soil were those of Allen *et al.* (1974). The importance value (IV) of perennial plant species was estimated by calculating the density, frequency and cover (IV = relative density + relative frequency + relative cover) according to Bauer (1943) and Ayyad (1970). Species identification and nomenclature are according to Tackholm (1974) and Davis (1978).

Seed Germination

The seeds were collected from living plants at the peak fruiting time. Seeds were separated from fruits and hand sorted, where unfilled or shrunken seeds excluded. The sorted seeds were placed in tightly closed vials and stored in the dark at room temperature. Germination tests were carried out in covered glass Petri dishes (9 × 1.5 cm) on one layer Whatman No. 1 filter paper, saturated with distilled water or test solution. Tests were performed with 50 seeds per dish and five replications per treatment. Dishes were placed in controlled incubator and germination counts made at daily intervals for 20 days.

Germination value (GV), *i.e.*, the expression of speed and totality of germination, and their interaction as a single numerical value (cf. Hegazy *et al.* 1990) was estimated as follows: GV = PV × MDG, where PV is the peak value, and MDG is the mean daily germination.

Effect of Temperature.

The effect of constant temperature was determined at 5°C increments between 5 and 45°C. For alternating night-day temperatures, the following thermoperiod trials were used: 10/20, 10/25, 15/25, 15/30, 20/30 and 25/35 °C. The incubator was programmed for 12 hours day (light) which accompanied the highest temperature.

Effect of Salinity

Saline solutions of 1,3,5,10,15,20,25 and 30×10^3 ppm sodium chloride were used. Distilled water was used as control treatment. The test was conducted at alternating night/day temperatures of 15/25 °C and 12 hour day length. Constant salt concentrations in the Petri dishes were maintained by adding distilled water equivalent to the evaporated water every two days.

Effect of Sowing Depth.

Germination was conducted in plastic pots of 9 cm diameter and 14 cm depth. Pots were filled with sterilized soil collected from the plant's natural habitat shortly before the start of the experiment. Sets of 100 seeds were placed in pots on the soil surface and at depths of 1,2,3,4 and 5 cm. Pots were stood in a shallow plastic trays which were used to provide moisture from below. Seedling emergence was observed every two days for 50 day experimental period.

Resource Allocation

For determination of phytomass allocation, 10 individual plants per growth stage for the seedling, juvenile, flowering/fruiting and fruiting/senescing stages were carefully excavated. Plants were subsequently partitioned into root, stem, leaf, flower and fruit components. Parts were oven dried at 85°C for three days and the dry weight

of each component was expressed as a percentage of the total dry weight of each individual.

Phenology

Phenological spectrum was constructed based on one year observations. Individual plants were randomly chosen and marked in the study area. Biweekly observations were carried out on the different phenological stages. Four phenophases were distinguished; vegetative, flowering, fruiting and senescing phases.

Anatomical Study

Root portions with buds were sampled from plants growing naturally in the study area. The material was fixed in formalin-acetic acid ethanol (FAA). Customary methods were followed to process the roots for paraffin embedding (O'Brien and McCully 1981). Sections were cut on a rotatory microtome at thickness of 10 μm, and stained with the safranin fast green combination.

Mitotic Preparation and Karyotype Technique

Root tips were collected from seedlings naturally growing in the field. The tips were treated in 0.002 M 8-hydroxyquinoline for about 3 hours (Tjio and Levan 1950) and fixed in acetic-alcohol (1:3) for one hour, stained with 2% aceto-orcein and squashed following the procedure reported by La Cour (1941). Prints were developed and karyotype was made up for the chromosome measurements. The chromosomes were classified in relation to their centromeric position, according to the scheme proposed by Abraham and Prasad (1983).

Meiotic Preparation

Flower buds were collected between 10 - 11 a.m., fixed immediately in a fresh mixture of absolute alcohol, chloroform and glacial acetic acid (6:3:1v/v). The anthers were stained in 2% aceto-orcein and squashed on the slide.

Pollen Fertility

Mature flower buds were fixed in the same fixative of meiotic preparation. Anthers were stained and squashed in 2% aceto-orcein. Estimation of pollen fertility was carried out as the ability of the pollen to accept the stain (Sarker *et al.* 1973). All deeply stained grains were counted as functional, while the non-stained or poorly stained ones with irregular outline were considered sterile.

Results

Soil

Table 1 shows the results of physical and chemical properties of the soil. Soil texture is formed mainly of coarse fractions. The moisture content, porosity and water-holding capacity are relatively moderate. Calcium carbonate and organic carbon content are low. Soil is alkaline in reaction with high salinity. The anions are mainly chlorides, sulphates, partly bicarbonates and carbonates. Sodium is the highest among all cations. In general, the soil types are siliceous, alkaline and salt affected.

Table 1. Physical and chemical characteristics of the soil samples collected from four stands of *Heliotropium curassavicum* community types in the study area

Soil variable	Stand 1	2	3	4	Mean (SE)
Fine fraction(%)	0.10	0.20	0.80	0.20	0.33 (0.14)
Coarse fraction(%)	99.90	99.80	99.20	99.80	99.68 (0.14)
Porosity (%)	37.60	37.40	38.00	41.00	35.50 (0.73)
W.H.C. (%)	29.28	29.00	38.76	36.13	33.29 (2.13)
Calcium carbonate (%)	0.57	1.13	1.38	0.88	0.99 (0.15)
Organic carbon (%)	0.10	0.10	0.17	0.07	0.11 (0.02)
pH value	8.50	9.35	8.80	8.80	8.86 (0.15)
E.C. (mmhos/cm)	0.80	1.40	3.86	5.25	2.77 (0.89)
Cl^- (%)	0.12	0.11	0.53	0.98	0.44 (0.18)
SO_4^{--} (%)	0.20	0.26	0.53	0.51	0.38 (0.07)
CO_3^- (%)	0.02	0.06	0.05	0.04	0.04 (0.01)
HCO_3^- (%)	0.13	0.14	0.08	0.09	0.11 (0.01)
Sodium (mg/100 g soil)	121.35	175.95	363.12	457.99	279.60 (68.28)
Potassium	20.70	35.98	31.97	34.80	30.86 (3.02)
Calcium	2.33	3.80	47.90	48.80	25.71 (11.33)
Magnesium	5.35	1.07	50.54	85.11	35.52 (17.29)

W.H.C. = water holding capacity
E.C. = electrical conductivity

Vegetation

The vegetation composition of the community of *H.curassavicum* is shown in Table 2. The community type comprises nine perennial species, with *H.curassavicum* attaining the highest importance value of 118.2 out of total 300. The associated perennial species belong to three different life forms; phanerophytes, chamaephytes

Table 2. Importance value (out of 300) of the perennial plant species associated with *Heliotropium curassavicum* community types in the study area

Plant species	Stand				Mean
	1	2	3	4	
Heliotropium curassavicum	80.0	236.6	12.6	143.5	118.2
Cressa cretica	–	–	243.9	31.5	68.9
Cynodon dactylon	181.4	44.1	32.5	13.9	68.0
Tamarix tetragyna	–	–	7.4	78.7	21.5
Alhagi graecorum	38.6	19.3	1.3	–	14.8
Aeluropus lagopoides	–	–	1.9	20.2	5.5
Polygonum equisetiforme	–	–	–	6.0	1.5
Sporobolus spicatus	–	–	0.4	3.1	0.9
Arthrocnemum macrostachyum	–	–	–	3.1	0.8

Associated annual plant species:

Amaranthus graecizans, A. viridis, Anagallis arvensis, Atriplex prostrata, Bassia muricata, Beta maritima, Cakile maritima, Chenopodium ambrosiodes, C. glaucum, C. murale, Conyza bonariensis, Datura innoxia, Erodium laciniatum, Heliotropium supinum, Juncus bufonius, Lotus halophilus, Melilotus albus, Mesembryanthemum nodiflorum, M. crystallinum, Ononis serrata, Parapholis incurva, Polypogon monospeliensis, Reichardia tingitana, Rumex pictus, Salsola kali, Senecio glaucus, Solanum nigrum, Sonchus oleraceus, Sphenopus divaricatus, Suaeda maritima, Xanthium pungens and *X.spinosum.*

and geophytes with various importance values. The associated therophytes are many and include a mixture of psamophytes, halophytes and weeds.

Seed Germination

Effect of Temperature.

The seeds have germinated over a constant temperature range between 10 and 40°C, with narrow optimum around 25°C, where the germination value reached 246 (Fig.1). At the tested alternating night/day temperatures, germination values were higher than the values at constant temperatures with an optimum value of 336 at 15/30°C night-day temperature.

Effect of Salinity.

Slightly elevated salinity from 0 to 1000 ppm has increased the germination value from 336 to an optimum value of 386. The values decreased steadily with increasing salinity from 1000 ppm onwards (Fig.2). At 10,000 ppm salinity level, the germination value dropped to about 6 times less than its optimal value. The germination was completely inhibited at all salt concentrations higher than 25,000 ppm.

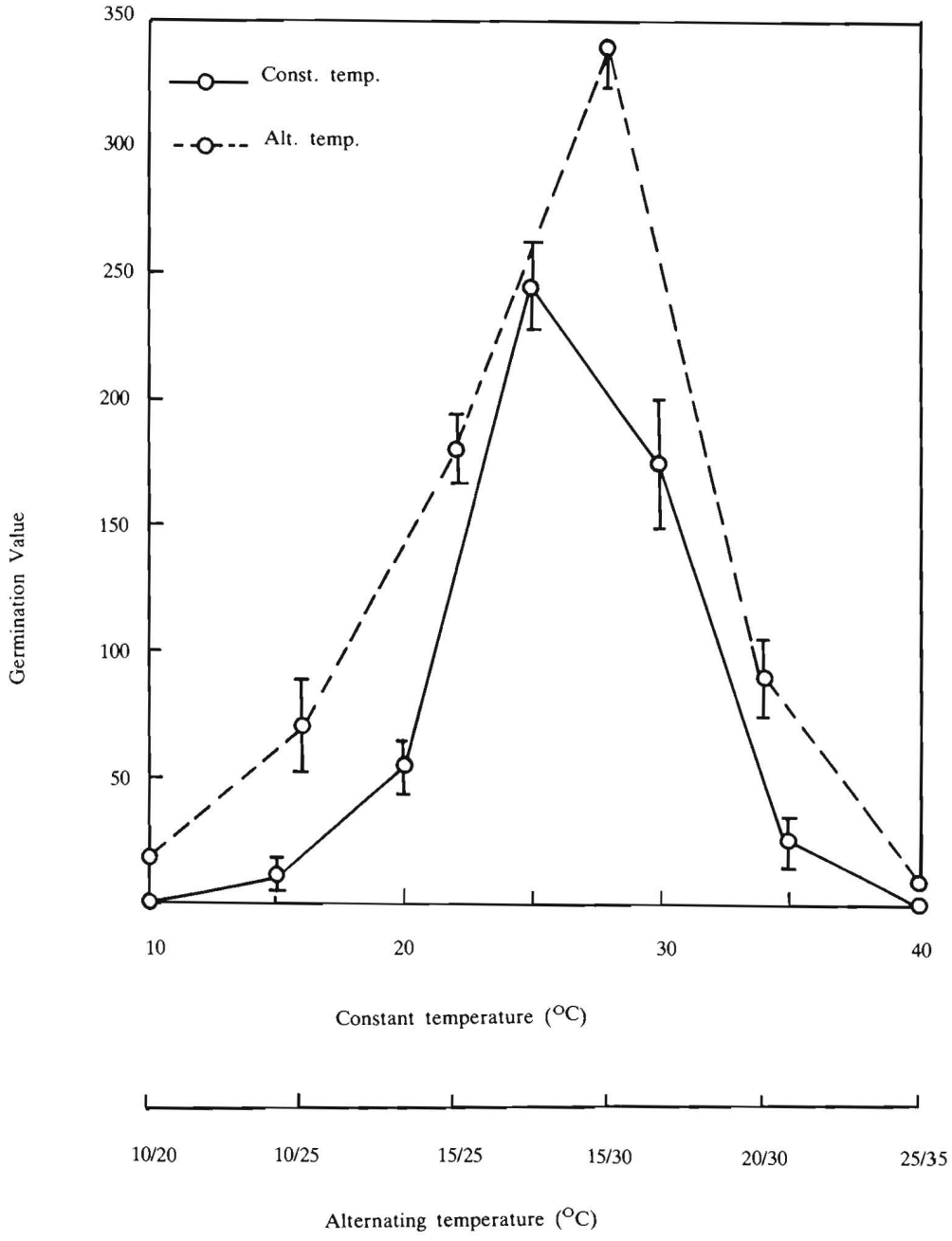

Fig. 1. Effect of constant and alternating night/day temperature on seed germination of *Heliotropium curassavicum*.

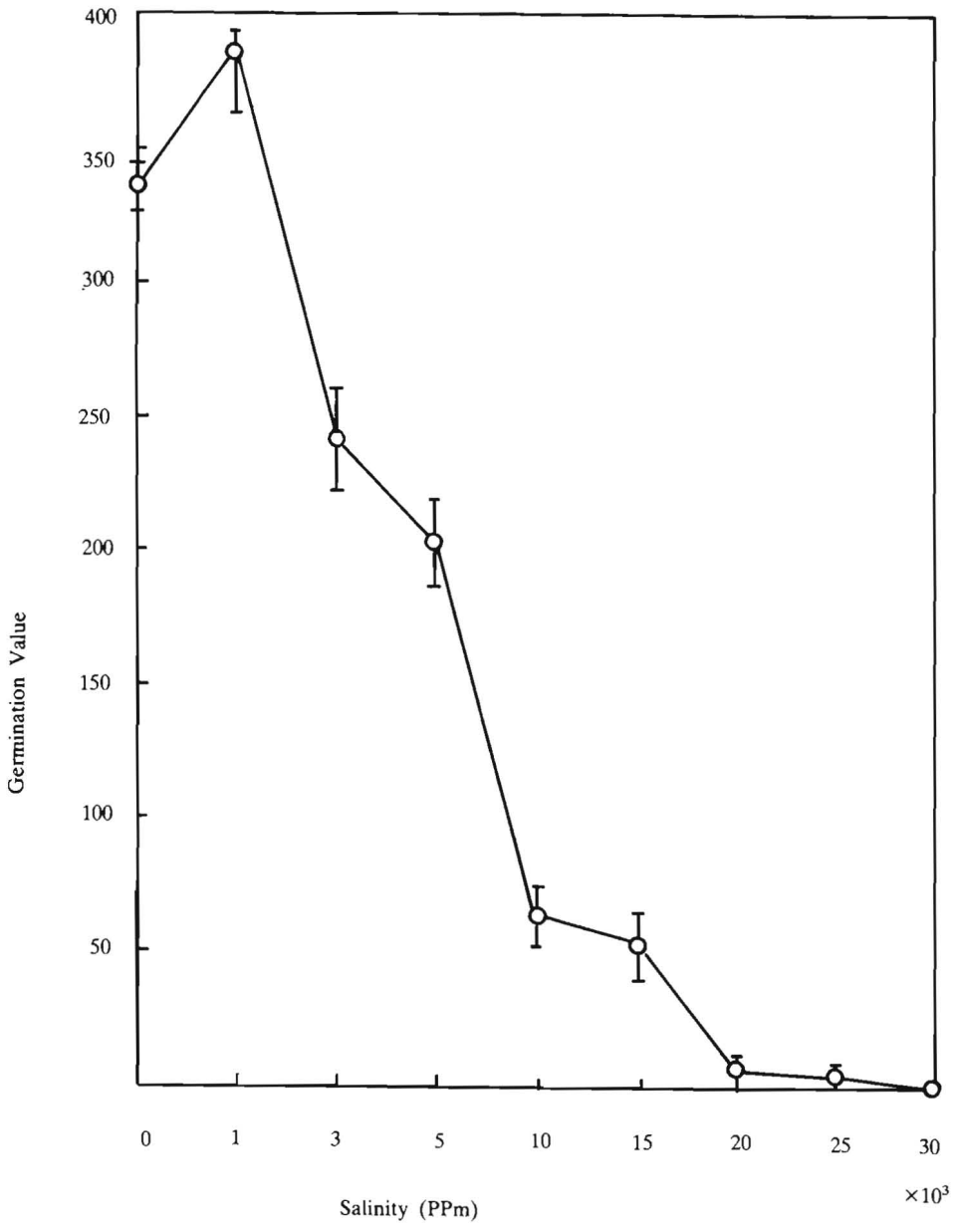

Fig. 2. Effect of salinity on seed germination of *Heliotropium curassavicum*.

Effect of Sowing Depth.

Germination sharply increased with the increase of sowing depth from the surface (O depth) to an optimum depth of about 1 cm. The germination value reached 25 for seeds sown at 1 cm depth (Fig.3). Seeds sown deeper than 1 cm showed gradual decrease in germination with the increase of sowing depth. All seeds sown deeper than 3 cm failed to germinate.

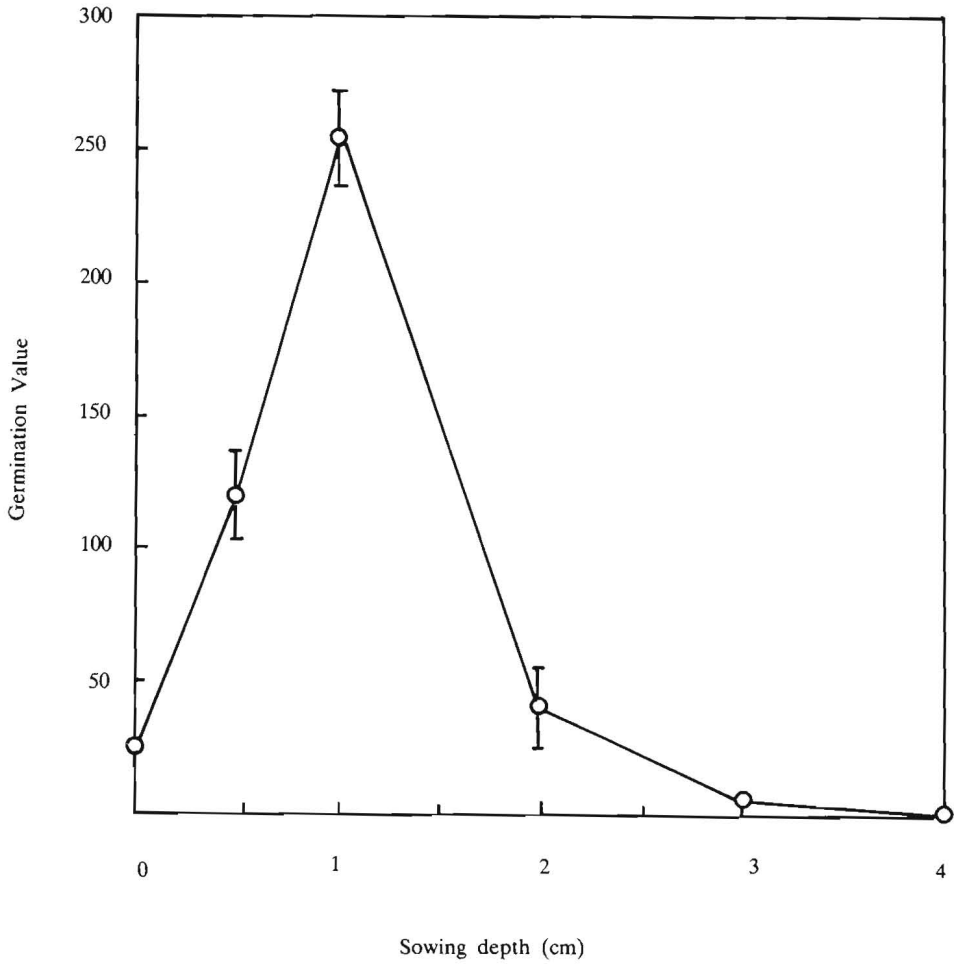

Fig. 3. Effect of sowing depth on seed germination of *Heliotropium curassavicum*.

Seedling Growth.

The effect of constant temperature on seedling growth was different from that of the alternating night/day temperatures (Table 3). Both root (R) and shoot (S) growth showed an optimal response to the constant temperature with an optimal root length of 1.8 cm and shoot height of 0.9 cm at incubation temperature of 25°C. Meanwhile, the R:S ratio showed a gradual decrease with the temperature increase. Variation of the R:S ratio under alternating night/day temperature was restricted within a narrow range from 1.91 to 2.25 under 15/30 and 20/30 °C night/day temperatures, respectively.

Table 3. Root-Shoot ratio under the tested germination conditions after 20 days experimental period. Standard deviation in brackets

Germination condition		Root length (cm)	Shoot length (cm)	Root- shoot ratio
Temperature (°C)				
(a) Constant	15	0.5 (0.2)	0.2 (0.1)	2.5 (0.7)
	20	0.9 (0.3)	0.4 (0.1)	2.3 (0.6)
	25	1.8 (0.5)	0.9 (0.2)	2.0 (0.4)
	30	1.3 (0.4)	0.7 (0.2)	1.9 (0.5)
	35	0.3 (0.1)	0.2 (0.1)	1.5 (0.3)
(b) Alternating night/day	10/20	0.4 (0.2)	0.2 (0.1)	2.0 (0.4)
	10/25	0.8 (0.3)	0.4 (0.1)	2.0 (0.5)
	15/25	1.5 (0.5)	0.7 (0.2)	2.1 (0.2)
	15/30	2.1 (0.6)	1.1 (0.4)	1.9 (0.3)
	20/30	1.8 (0.6)	0.8 (0.3)	2.3 (0.5)
	25/35	0.4 (0.1)	0.2 (0.1)	2.0 (0.4)
Salinity (ppm)	Control	2.1 (0.3)	1.1 (0.3)	1.9 (0.5)
	1×10^3	2.0 (0.4)	0.9 (0.2)	2.2 (0.4)
	3×10^3	1.7 (0.4)	0.8 (0.3)	2.1 (0.3)
	5×10^3	1.2 (0.3)	0.6 (0.2)	2.0 (0.4)
	10×10^3	0.8 (0.2)	0.3 (0.1)	2.7 (0.4)
	15×10^3	0.5 (0.1)	0.3 (0.1)	1.7 (0.3)
	20×10^3	0.2 (0.1)		0.2 (0.1)
	25×10^3	0.2 (0.1)		0.2 (0.1)
Depth of sowing (cm)	0.0	1.3 (0.3)	0.8 (0.2)	1.6 (0.3)
	0.5	3.6 (0.7)	1.3 (0.3)	2.8 (0.5)
	1.0	4.3 (0.6)	1.5 (0.4)	2.9 (0.5)
	2.0	4.2 (0.8)	2.1 (0.4)	2.0 (0.3)
	3.0	2.6 (0.5)	3.2 (0.6)	0.8 (0.2)

The different salinity treatments have resulted in decreased root and shoot growth of the seedlings. The R:S ratio decreased from 2.22 at salinity level of 1000 ppm to 0.20 at 25000 ppm (Table 3). At high salinity concentrations, there were no shoot development.

The response of seedling growth to sowing depth was different in roots from shoots (Table 3). The root length increased from 1.3 cm at 0.0 cm to optimal length of 4.3 cm at 1.0 cm depth, then decreased with the increase of sowing depth. The shoot height showed steady increase with depth, and ranged from 0.8 cm at the surface sowing to 3.2 cm height at 3.0 cm sowing depth. The R:S ratio showed an optimal response to the sowing depth and attained an optimal value of 2.87 at 1.0 cm sowing depth.

Resource Allocation

Age-specific pattern of phytomass allocation of different plant organs varied over time (Fig.4a).About 53 , 65and 67% of dry phytomass were allocated to roots in the seedling, flowering/fruiting and fruiting/senescing stages, respectively. In the juvenile stage, the highest value of dry matter (about 37%) was allocated of the stems. The age-specific least amount of dry matter was allocated to the leaves in the different growth stages. In flowering/fruiting and fruiting/senescing stages, the dry matter allocation to flowers and fruits occurred at the expense of leaves and stems, where their values decreased to about one third its values in the juvenile stage. During flowering/fruiting and fruiting/senescing stages, the root dry weight increased to about two times its value, in the juvenile stage.

Phenology

The phenological spectrum during the year of observation is shown in Fig. 4b. Vegetative growth occurred throughout about 10 months from late January to October. Dormancy period was mainly restricted from late November to early January. Flowering started in February and extended to the end of October, with an average period of flowering of about 8 months. Fruiting pattern was parallel to the flowering activity. Senescence extended over 3 month period from September to November.

Root Buds

Cross section showed the presence of growing adventitious root buds. The roots are wrinkled over the place of origin of the root buds. These bulges, consisting of periderm, phelloderm and cortex, with secondary growth taking place at early stages of root growth (Plate 1). Initiation of the root buds appears to be pericyclic in origin. The buds are often twisted within the cortex before emergence. The apex of the bud is observed growing centripetally, *i.e.*, towards the exterior of the root. A considerable amount of parenchyma cells are filling the root centre, and consequently, the cells become distended and the xylem vessels more widely separated from one another.

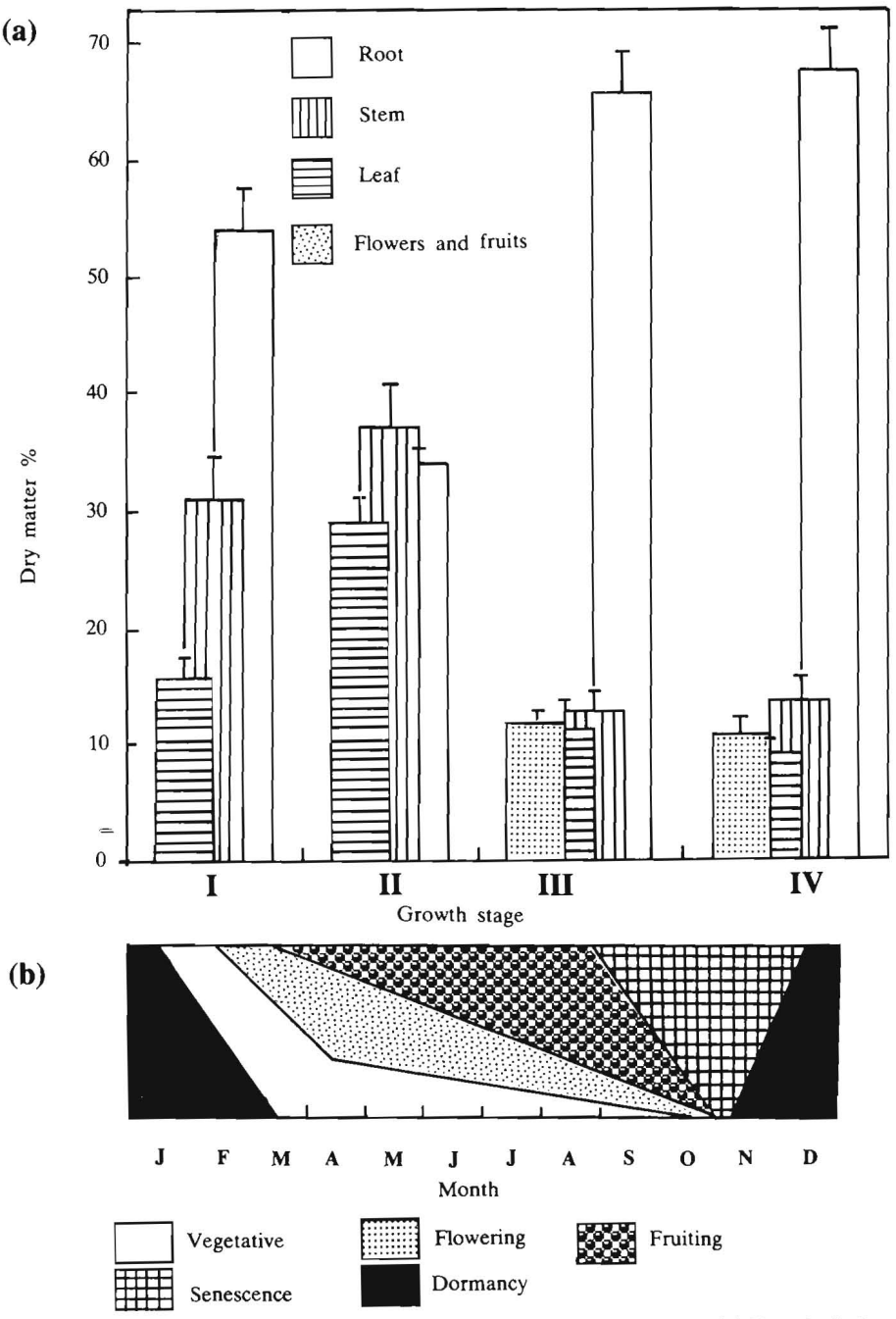

Fig. 4. (a) Age-specific pattern of phytomass allocation to different plant organs. (b) Phenological spectrum during the year of observation. Growth stage I = Seedling, II = Juvenile, III = Flowering fruiting, and IV = Fruiting senescing.

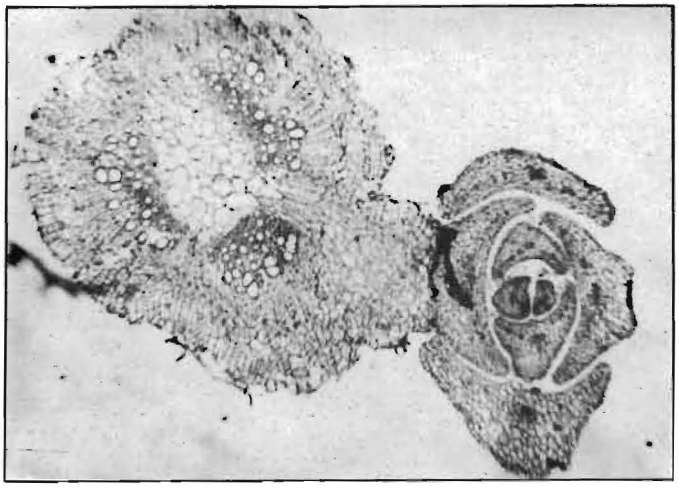

Plate 1. Transverse section in the root of *H. curassavicum* with the developing root bud.

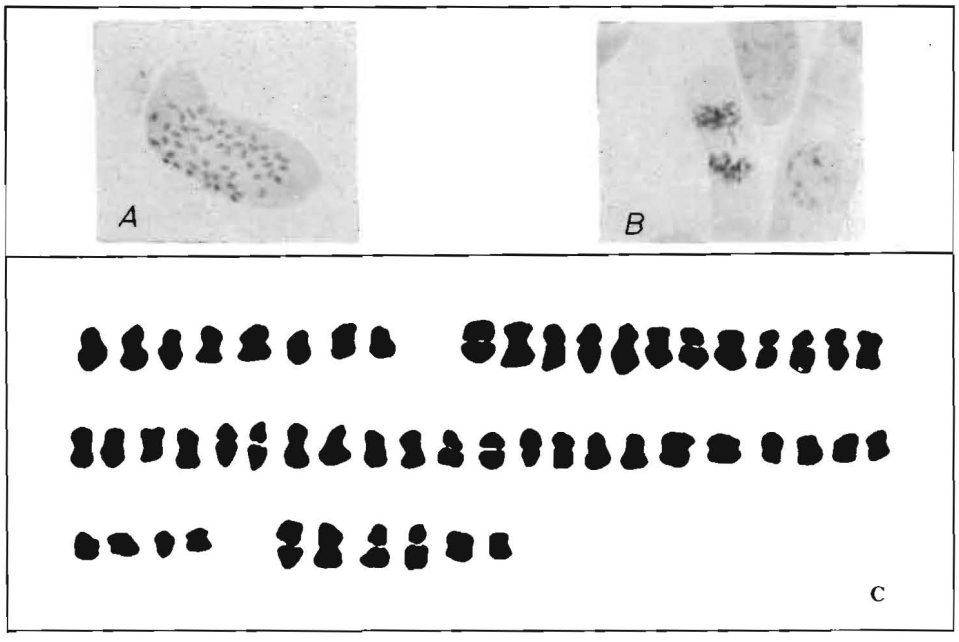

Plate 2. **(A)** Somatic chromosomes of *H. curassavicum.*
(B) Irregular cell division showing laggard chromosomes.
(C) Karyograms of *H. curassavicum.* The karyotype formula is 8 nsm(−), 38 nm and 6 m. where nsm = nearly submetacentric, nm = nearly metacentric, and m = metacentric.

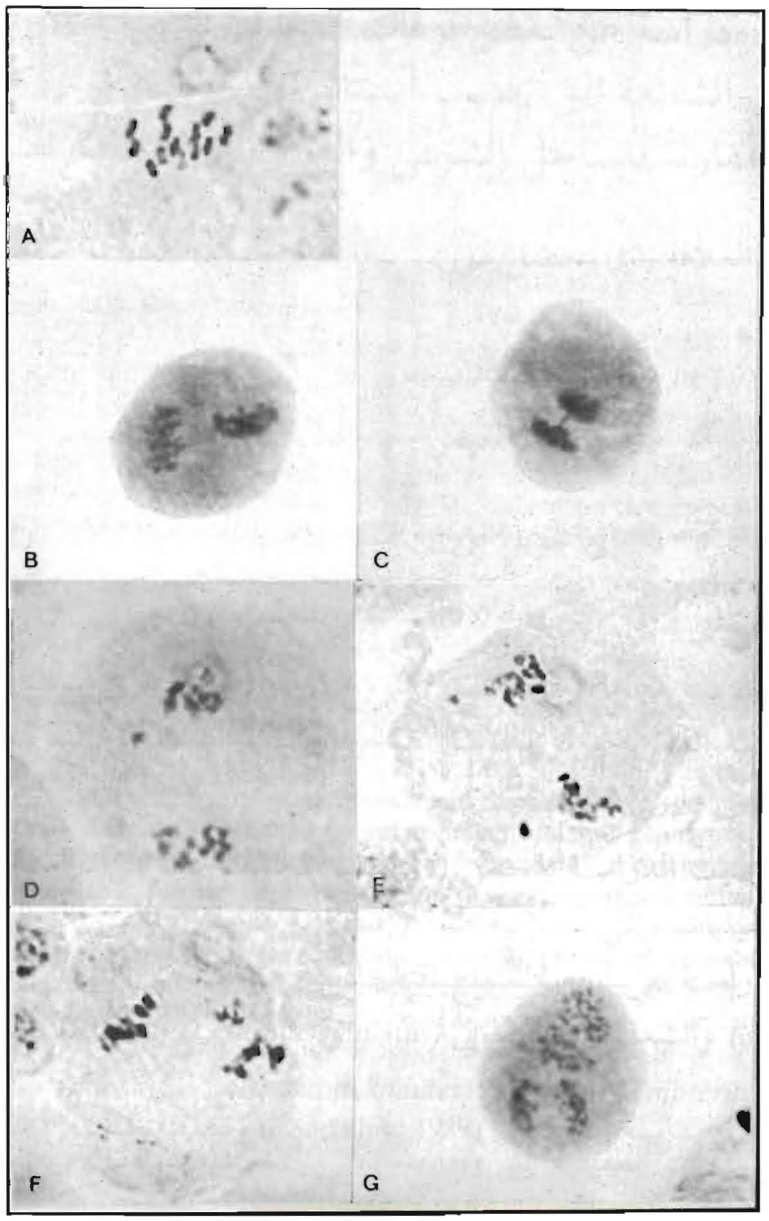

Plate 3. Meiotic cell division of *H. curassavicum*. (A) Thirteen bivalents at diakinesis, (B) Mis-orientation in division II. (C) Bridge in division I, (D) Laggard in division I, (E) Two laggards in division II, (F) Stickiness and laggard in division I. and (G) Asynchrony in division II.

Cell Division

The observed somatic chromosome number was 2n = 52 (Plate 2A). The total chromosome length ranged between 0.29 to 0.66 μm with a total complement length of 24.64 μm. *Heliotropium curassavicum* karyotype is represented in Plate 2C where 8 nsm (-), 38 nm and 6 m chromosomes were noticed. A considerable variation was found in arm ratio which ranged between 1.00 to 2.35.

Chromosomal aberrations were observed in both mitotic and meiotic divisions. Irregular mitotic division was found in some cells which had laggard chromosomes (Plate 2B). Chromosomal abnormalities were also observed in the first and second meiotic division (54.10% of cells). The first division showed chromatin bridge, laggards and stickiness of the chromosomes (Plate 3C, D and F). These abnormalities occur in 30% of the cells, with laggards occurring in most cases. In the second division, misorientation, laggards and asynchrony were observed (Plate 3B, E and G). These abnormalities occur in 24.1% of the cells. The majority of the abnormalities were asynchrony.

The abnormal meiotic division was associated with reduction of pollen fertility. About 72% of the pollen grains were non-fertile.

Discussion

Evolution and fast spreading of *Heliotropium curassavicum* as a weed in the newly reclaimed salt affected sandy lands of the Deltaic Mediterranean coast represents a serious problem. In this new agroecosystem, other wild plants have become poorly adapted to the prevailing environment where selection pressure is very strong. This can be supported by the dominance of *H. curassavicum* over the other wild species in the study area.

The continuous disturbance due to agricultural practices, often bury the seeds or expose them to wide range of night/day surface soil temperatures. The average night/day soil temperature is usually less than the optimuim germination temperature of *H. curassavicum*. This may, explain the generally low germination which did not exceed 25%. Also reflects the mechanism by which the seeds are protected from germinating too early in the growing season where seedlings may be subjected to cold spells or slight frost of short duration in the early winter (Hegazy and Moser 1991).

When seeds were germinated under gradual increase in salinity, the germination under salinity level of 1000 ppm attained the highest value. The optimal germination and successful seedling establishment of *H. curassavicum* occurs only after enough precipitation which ensures low salinity level of the upper soil layers by, washing and infiltration of soil salts. Due to this behaviour, the seeds avoid increased salinity which may cause insufficient hydration of the seeds (Harper and Benton 1966, Koller and

Hadas 1982, Agami 1986) and insufficient oxygen supply (Mayer and Poljakoff-Mayber 1982). The seeds showed low germination values around the optimum temperature. This may indicate that salinity is more important in germination control than temperature.

The better germination around 1 cm sowing depth reveals that, such depth may, protect the seed bed from rapid desiccation during germination and against the direct effect of light and temperature (cf. Mashaly *et al.* 1993). Meanwhile, due to soil disturbance, seeds are buried at different levels, that helps the persistence of intermittent germination and seedling appearance, a perfect adaptation of a successful weed (Dubey and Mall 1972). The better germination of seeds buried in the uper surface layers reveals that most of the dormancy, mechanisms are operative in the upper soil layers (Harper 1977).

The seedlings showed a comparable root and shoot growth. The root growth exceeded that of the shoot. Only, under marginal conditions, such as high salinity levels (more than 20,000 ppm), low and high temperatures (less than 15°C and higher than 35°C), and at the sowing depth of 3 cm, the root/shoot ratios were less than unity.

Pattern of phytomass allocation to root, stem and leaf showed the same trends for seedling, flowering/fruiting and fruiting/senescing stages in, a descending order of root > stem > leaf. Only in the juvenile stage, there were significant increase in the stem and leaf phytomass at expense of the root. This is not surprising for a rapidly spreading weed where vigorous leaf and stem growth during the juvenile stage is required for building up nutrients for further vegetative growth and storing in roots. This consistent phytomass allocation throughout the different growth stages suggested a highly synchronized pattern through the life cycle (Grace and Wetzel 1982, Matthies 1990, Hegazy 1992).

The flowering and fruiting cycle goes parallel to the vegetative cycle and extend throughout the year. This seems to be related to the nutrients reserved in roots which further used for both sexual and vegetative propagation (Hegazy 1994). There were large amounts of reserved nutrients in roots of adult individuals as inferred by high phytomass (> 65%). With the breaking of dormancy in late winter/early spring, the stored nutrients are utilized in the rapid sprouting of dormant buds and fast growth of the new shoot sprouts.

Numerous species of weeds are perennials and that their success in the disturbed environments is dependent in part on effective mechanisms of vegetative propagation. Among these mechanisms, the production of adventitious root buds (Priestly and Swingle 1929, Peterson 1975). The success of *H. curassavicum* as a weed can be attributed to a large extent to its ability to produce adventitious root buds which allow for the plant's perennation and spread.

Many chromosomal abnormalities were found in both mitotic and meiotic divisions. These abnormalities included laggard chromosomes, chromatin bridge, stickiness, mis-orientation and asynchrony. This irregular chromosome behaviour was reported in many other speciess (Walters 1956, Vasek 1962, Newman 1959, 1966 and 1967, Vig 1968, Star 1970). It is not known how much of the chromosomal abnormalities is genetic. However, Suto (1955) found a recessive gene in maize which caused a high frequency of aborted pollen. Lesley and Frost (1972) reported a recessive gene in cultivated *Matthiola incana*. This behaviour have increased the length of the chromosomes during meiosis and also decreased the degree of pairing. It has often been suggested that weeds show a greater tendency than other types of plants towards polyploidy which is often associated with an increase in vegetative growth and vigour of plants in addition of higher rate of sterility (Hill 1977). This may explain the shift from sexual to asexual reproduction in *H. curassavicum* (Hegazy 1994).

The reduction of pollen fertility in many plants is often associated with irregular meiosis of pollen mother cells (Brown 1972), where this leads to the production of non-functional gametes. This can be related to the meiotic process in this species. The environmental factors which are most likely to be associated with reduced pollen viability are temperature and day length (Jones and Clarke 1943). Also, Heslop-Harrison (1972) has suggested that starvation due to inadequate nutrient supply is a common cause of pollen sterility, although other parts of the flower are apparently unaffected.

In conclusion, the success of *Heliotropium curassavicum* as a weed can be attributed to many factors, among these factors are: strong selection pressure, persistence of intermittent seed germination and seedling establishment, synchronized pattern of phytomass allocation and phenological events, ability to produce adventitious root buds, chromosomal abnormalities and reduced pollen fertility that made the species to shift from sexual to vegetative reproduction.

References

Abraham, Z.and **Prasad, P.N.** (1983) A system of chromosome classification and nomenclature *Cytologia*, **48:** 95-101.

Agami, M.(1986) The effects of different soil water potentials, temperature and salinity on germination of seeds of the desert shrub *Zygophyllum dumosum*. *Physiol. Plant.* **68:** 305-309.

Allen, S.E., Grimshaw, H.M., Parkinson, J.A. and **Quarmby, C.H.** (1974) *Chemical Analysis of Ecological Materials*. Oxford, Blackwell.

Ayyad, M.A. (1970) Application of the point-centered quarter method to the vegetation of two types of desert habitat at Mareotis, *Egypt. J. Bot.* **13:** 225-234.

Baker, H.G. (1974) The evolution of weeds. *Ann. Rev. Ecol. Syst.* **5:** 1-124.

Bauer, H.L. (1943) The statistical analysis of chaparral and other plant communities by means of transect samples. *Ecology*, **24:** 45-60.

Brown, W.V. (1972) Textbook of Cytogenetics. Mosby, C.V. St. Louis.

Catalfamo, J.L., Martin, W.B., Jr. and **Birecka, H.** (1982) Accumulation of alkaloids and their necines in *Heliotropium curassavicum, H. spathulatum* and *H. indicum Phytochemistry*, **21:** 2669-2675.

Davicino, J.G., Pestchanker, M.J. and **Giordano, O.S.** (1988) Pyrrolizidine alkaloids from *Heliotropium curassavicum, Phytochemistry*, **27:** 960-962.

Davis, P.H. (1978) *Flora of Turkey and the East Aegean Islands. Edinburgh Univ. Press. U.K.* **6:**

Dubey, P.S. and **Mall, L.P.** (1972) Ecology of germination of weed seeds. I. Role of temperature and depth of burial in soi. *Oecologia*, **10:** 105-110.

Frohlich, M.W. (1980) In chromosome number reports LXIX. Taxon, **29:** 705.

Grace, J.B. and **Wetzel, R.G.** (1982) Niche differentation between two rhizomatous plant species: *Typha latifolia* and *T. angustifolia. Can. J. Bot.* **60:** 46-57.

Grime, J.P. (1979) *Plant Strategies and Vegetation Processes*. John Wiley and Sons, London, U.K.

Harper, J.L. (1977) *Population Biology of Plants*. Academic Press, London, U.K.

Harper, J.L. and **Benton, R.A.** (1966) The behaviour of seeds in soil. II. The germination of seeds on the surface of a water supplying substrate. *J. Ecol.* **54:** 151-166.

Hegazy, A.K. (1994) Trade-off between sexual and vegetative reproduction of the weedy *Heliotropium curassavicum* L. (Boraginaceae). *J. Arid. Environ.* **27:** 209-220.

Hegazy, A.K. (1992) Age-specific survival, mortality and reproduction and prospects for conservation of *Limonium delicatulum. J. Appl. Ecol.* **29:** 549-557.

Hegazy, A.K. and **Moser, W.** (1991) Water use efficiency, photosynthesis, extreme temperature and drought tolerance of desert plant seedlings. Folia Geobot. Phytotax., *Praha*, **26:** 263-276.

Hegazy, A.K., Mansour, K.S. and **Abdel-Hady, N.F.** (1990) Allelopathic and autotoxic effects of *Anastatica hierochuntica* L., *J. Chem. Ecol.* **16:** 2183-2193.

Heslop-Harrison, J. (1972) Sexuality of angiosperms. *In:* **Steward, F.C.** (ed.) *Plant Physiology*, Academic Press, London, U.K. **6**(C): 133-189.

Hill, T.A. (1977) The Biology of Weeds. Studies in Biol., No. 79. Edward Arnold, London.

Jones, H.A. and **Clarke, A.E.** (1943) Inheritance of male sterility in the onion and the production of hydrid seed. *Proc. Amer. Soc. Hort. Sci.* **43:** 189-194.

Koller, D. and **Hadas, Y.** (1982) Water relations in the germination of seeds. *In:* **Lange, O.L., Nobel, P.S., Osmond, C.B.** and **Ziegler, H.** (Eds.) Encyclopedia of Plant Physiology. Springer-Verlag, Berlin. **12**(B): 401-431.

La Cour, L. (1941) Acetic Orcein. *Stain Tech.* **16:** 169-174.

Lesley, M.M. and **Frost, H.B.** (1972) Mendelian inheritance of chromosome shape in *Matthiola. Genetics*, **12:** 449-460.

Mashaly, I.A. (1987) *Ecological and Floristic Studies of Dakahlia-Damietta Region.* Ph.D. Thesis, Univ. of Mansoura, Egypt.

Mashaly, I.A., Hegazy, A.K. and **Soliman, M.I.** (1993) On the ecology of *Zygophyllum aegyptium* in Egypt. *Tasks Veg. Sci.* **27**(1): 423-433.

Matthies, D. (1990) Plasticity of reproductive components at different stages of development in the annual plant *Thlaspi arvense* L. *Oecologia,* **83:** 105-116.

Mayer, A.M.and **Poljakoff-Mayber, A.** (1982) *The germination of Seeds.* 3rd Ed. Pergamon Press.

Miller, J.S.(1988) A review treatment of Boraginaceae for Panama. Ann. Missouri Bot. *Gard.* **75:** 456-521.

Mohanraj S., Subramanian, P.S. and **Herz, W.** (1982) Minor alkaloids of *Heliotropium curassavicum. Phytochemistry,* **21:** 1775-1779.

Mooney, H.A. (1980) Photosynthetic plasticity of populations of *Heliotropium curassavicum.* L. originating from differing thermal regimes. *Oecologia,* **45:** 372-376.

Muzik, T.J. (1970) *Weed Biology and Control.* McGraw-Hill, New York.

Newman, L.J. (1959) Chromosomal aberrations in *Podophyllum peltatum. Evolution,* **13:** 276-279.

Newman, L.J. (1966) Bridge and fragment aberrations in *Podophyllum peltatum. Genetics,* **53:** 55-63.

Newman, L.J. (1967) Meiotic chromosomal aberrations in wild populations of *Podophyllum peltatum. Chromosoma (Berlin),* **22:** 258-273.

O'Brien, T.P. and **McCully, M.E.** (1981) The study of plant structure: principles and selected methods. Termarcarphi Pty Ltd., Australia.

Peterson, R.L.(1975) The initiation and development of root buds. *In:* **Torrey J.G.** and **Clarkson, D.T.** (Eds.) The Development and Function of Roots. Academic Press, New York. pp. 125-161.

Priestly, J.H. and **Swingle, C.F.** (1929) Vegetative propagation from the standpoint of plant anatomy. *U.S. Dept. Agric. Tech. Bull.,* **151:** 1-98.

Roy, J. and **Mooney, H.A.** (1982) Physiological adaptation and plasticity to water stress of coastal and desert populations of *Heliotropium curassavicum.* L. *Oecologia,* **52:** 370-375.

Sarker, A.K., Datta, N. and **Chatterjee, U.** (1973) In TOPB chromosome number reports. XLII. *Taxon,* **22:** 647-654.

Sen, D.N., Bhandari, D.C. and **Ashraf, N.** (1980) Adaptations for survival of weeds in the Indian arid regions. *J. Arid Environ.* **3:** 99-106.

Star, A.E. (1970) Spontaneous and induced chromosome breakage in *Claytonia virginica. Amer. J. Bot.* **57:** 1145-1149.

Subramanian, P.S., Mohanraj, S., Cockrum, P.A., Culvenor, C.C.J., Edgar, J.A., Frahn, J.L. and **Smith, L.W.** (1980) The alkaloids of *Heliotropium curassavicum. Aust. J. Chem.* **33:** 1357-1363.

Suto, T. (1955) Cytogenitical studies of male sterility in maize. I. On a case of genic semi-sterility. Bull. Natl. Inst. Agric. Sci. (Japan), Ser. D, *Plant Physiol.* **5:** 137-178.

Tackholm, V. (1974) Students' Flora of Egypt, 2nd Ed., Cairo University Press. Egypt.

Tjio, J.H. and **Levan, A.** (1950) The use of oxyquinoline in chromosome analysis. Anales de la Estac. Exper. *De Aula dei,* **2:** 21-64.

Vasek, F.C. (1962) Multiple-spindle a meiotic irregularity in *Clarkia exilis. Amer. J. Bot.* **49:** 536-539.

Vig, B.G. (1968) Spontaneous chromosome abnormalities in root and pollen mother cells of *Aloe vera* L., *Bull. Torrey Bot. Club* **95:** 254-261.

Walters, J.L. (1956) Spontaneous meiotic chromosome breakage in natural populations of *Paeonia californica. Amer. J. Bot.* **43:** 342-354.

(Received 16/02/1994;
in revised form 21/06/1994)

دراسة بيولوجية على نبات *Heliotropium curassavicum* في الساحل الشمالي لدلتا نهر النيل

أحمد كامل حجازي[١] و ماجدة سليمان[٢] و ابراهيم مشالي[٣]

[١]قسم النبات ـ كلية العلوم ـ جامعة قطر ـ دولة قطر
[٢]قسم النبات ـ كلية العلوم (فرع دمياط) ـ جامعة المنصورة ـ و
[٣]قسم النبات ـ كلية العلوم ـ جامعة المنصورة ـ مصر

يعتبر نبات *Heliotropium* المعمر من النباتات البرية التي تحولت إلى أعشاب زراعية، وينتشر في كثير من الأراضي المتأثرة بالملوحة والمستصلحة حديثاً في الساحل الشمالي لدلتا نهر النيل.

ويهدف هذا البحث إلى دراسة خواص إنبات البذور، توزيع المادة الجافة في أعضاء النبات، تكوين البراعم العرضية على الجذور، الانقسام الخلوي وخصوبة حبوب اللقاح.

وقد أوضح البحث النتائج التالية:

(١) التكيف البيئي لهذا النوع مكّنه من السيادة على الأنواع النباتية البرية الاخرى حيث تحول من نبات بري إلى عشب زراعي يسود في معظم الحقول الزراعية في الساحل الشمالي لدلتا نهر النيل.
(٢) القدرة الفائقة على إنتاج كميات كبيرة من البذور التي تنبت وتستوطن البادرات الأماكن المفتوحة مما يساعد على انتشار النبات بسرعة.

(٣) وجود ارتباط بين توزيع المادة الجافة في أعضاء النبات وشكل النبات خلال مراحل النمو على مدار العام.

(٤) القدرة على تكوين براعم عرضية على الجذور تعطي مجاميع خضرية تمكن النبات من الانتشار والتكاثر خضرياً.

(٥) وجود تشوهات في الكروموسومات خلال الانقسام الخلوي وقلة خصوبة حبوب اللقاح جعل النبات يعتمد على التكاثر الخضري عن طريق البراعم الخضرية بالاضافة إلى تكاثره الجنسي عن طريق البذور.