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TOWARDS A PROSPECTIVE TRANSPLANTATION OF THE LOCAL MANGROVE *AVICENNIA MARINA* (FORSSK.) VIERH. GROWING ON COAST OF QATAR
I. ECOPHYSIOLOGICAL PERFORMANCE OF JUVENILES.

By

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Key words: Mangrove propagules, survivorship, growth measuring.

ABSTRACT

A population sample of propagules was collected at random from average size *A. marina* trees growing at "Dhakhira" (Qatar). This sample was then divided into subsamples which were used to detect the effects of light intensity, salinity and pretreatment of propagules on their survivorship and on the different growth parameters of produced seedlings.

The higher radiation intensity (HRI) results in, on the average, lower survivorship of seedlings compared to those growing under lower radiation intensity (LRI). The highest survivorship is that for seedlings growing at lower salinity level under LRI. However, when growing on soil substrates at high salinity levels, higher survivorship results under HRI associated with much higher growth measures compared to those attained under LRI. Growth of seedlings under LRI and low salinity level is characterised by higher biomass and ash contents, and lower root ratio that results in larger number of leaves and of their total area associated with lower SLA and LAR. Consequently, the highest relative growth rate is attained for seedlings of this latter treament.

It is concluded that salinity level and radiation intensity have determinant effects on seedling growth so that proportional levels of these factors result in higher survivorship and growth. However, growth under LRI and low salinity, although have the highest survivorship, yet further investigation is necessary to test the effect of imposing salinity stress prior to transplantation.

INTRODUCTION

Avicennia marina tends to form the fringing vegetation along tidal water ways (Wells 1982). In Qatar, this species occupies the mud deposition in the characteristic intertidal basin behind the tidal delta that is building up at the north of "Dhakhira" embayment (Abdel-Razik in press). Its frontal belt in this area is partially intermingling with the salt marsh vegetation (Abdel-Razik and Ismail 1990).

Regeneration of *A. marina* population in Qatar is apparently less affected by the plant's biological attributes. For example, the loss of viability due to dehydration subsequent to shedding of its recalicitrant seeds (Farrant *et al.,* 1986) is unusual under daily inundation by sea water. While the physical environment imposes stronger determinant effects on dispersal and establishment of juveniles which mask the high inherent growth and reproducton values of parent trees (Abdel-Razik in press). On the other hand, the characteristic salt secreting glands in leaves and the high conservative water use strategy together the characteristic structural and functional attributes of roots suited to coping with highly slaine enviroments (Ball 1988a), support this mangrove species to grow over wide range of salinity. Concurrently, the buoyancy of its viviparous propagules is considered to support very young seedlings which are affected more by the waterlogging (Clarke and Hannon 1970).

The population of *A. marina* in Qatar forms open canopies with more frequent and vigor mature seedlings growing in the open (higher rediation intensity) at lower elevations as driven by tide, although subjected to higher salinity and watelogging of the substrate, than underneath or in the shade of the mature trees (lower radiation intensity). Therefore, differences in growth can be attributed to effects of salinity on redistribution of embryonic reserves (Ball 1986), and to a probable effect of variation in light intensity and duration time.

Experimentation with propagules in the present study is performed with the aim of getting the right perspective of the local *A. marina* population for a prospective transplantation and use of this mangrove species in Qatar.

MATERIAL AND METHODS

The single seeded (rarely double seeded) fruit of *A, marina* is abscised with the pericarp intact, whether readily dehiscent or not, late in summer. Those propagules that could be gently released from parent shrubs were collected at random from average size mature trees, kept in plastic bags and were transferred immediately to the laboratory. The average fresh and dry weight per propagule as well as its ash content was recorded using a sample of ten propagules.

A population sample of propagules with uniform features, as far as possible, was selected (400 propagules) and equally sub-divided into two groups. Both subsamples were then cultivated under natural light, temperature and relative humidity conditions so that one is facing the east and the other is toward the west at two sides of a barrier. The duration of direct solor radiation for the first goup of propagules started at sunrise (5 to 10 am), while that for the second group started successively (10 am to 15 pm), hence higher radiation intensity is assumed for the second group.

It is documented that the maximum rate of development and establishment of *A. marina* seedlings is attained in 50% sea water (cf. Connor 1969, Clarke and Hannon 1970, Ball 1986), while the optimal salinity for growth is substantially lower for mature seedlings, ranging from 10 to 25% sea water (cf. Downton 1982, Burchett *et al.,* 1984, Naidoo 1987; Ball 1988b). The presence of high salt concentraitons in seed and propagule reserves may enable temporary growth in fresh water habitats. Therefore, three treatments were conducted within each subsample of propagules; (A): cultivation on pots filled with soil bed (collected from underneath shrubs in th study site) and subirrigated with 50% sea water till seedling establishment, then using fresh water; (B): cultivation on peatmoss bed with no presoaking of propagules; and (C): cultivation on peatmoss bed after presoaking of propaguls in fresh water for one day until the pericarp was lifted away. Both treatments (B) and (C) were subirrigated with fresh water.

Germination and establishment of juveniles to immature palnts were recorded for 18 weeks, after which destrcutive harvesting of replica were carried out for each treatment within each of the main two subsamples of plants. These were used to determine the fresh and dry weights and the ash contents of leaves, stem and root per individual together with the number and total area of its leaves.

All treatments were transferred to the greenhuouse subject to uniform conditions of exposure to direct radiation (8 to 14 pm), and subirrigated with 15% sea water, which is intended to be increased gradually to 50% sea water prior to transplatation in its original location in the field for further investigations.

RESULTS

Phenological records in the study of the population structure of *A. marina* (Abdel-Razik, in press) indicates that the developlement of vegetative buds and early vegetative activity take place early in March. The plants start developing the flower buds during;April by the middle of the month about 50% of branches blooms. The peak of flower buds is attained in mid-May, 30% of which dies out, while about 40% enters the flowering stage. At mid-August, all trees set fruits and the mature propagules start shedding off.

The propagules of *A. marina* are abscised with the pericarp intact, and instantaneous growth takes place following release of propagules from the parent plant. All collected mature propagules show different features of initiation of growth while still intact to the tree. Of these features are: green enlarged cotyledons, hypocotyle elongation and active root primordia forming protrussions for lateral roots. The embryo has also cushions of hairs covering both its growing ends (Plate 1). Further development of embryo and subsequent growth takes place under wet conditions starting by rapid lifting away of the pericarp associated with rapid growth of hypocotyle and lateral roots. It is a matter of a few days when the propagules are established on the substrate and begin plumule growth. Eventually, the cotyledons open wide, the epicotyle emerges and the first two leaves become ready to unfold.

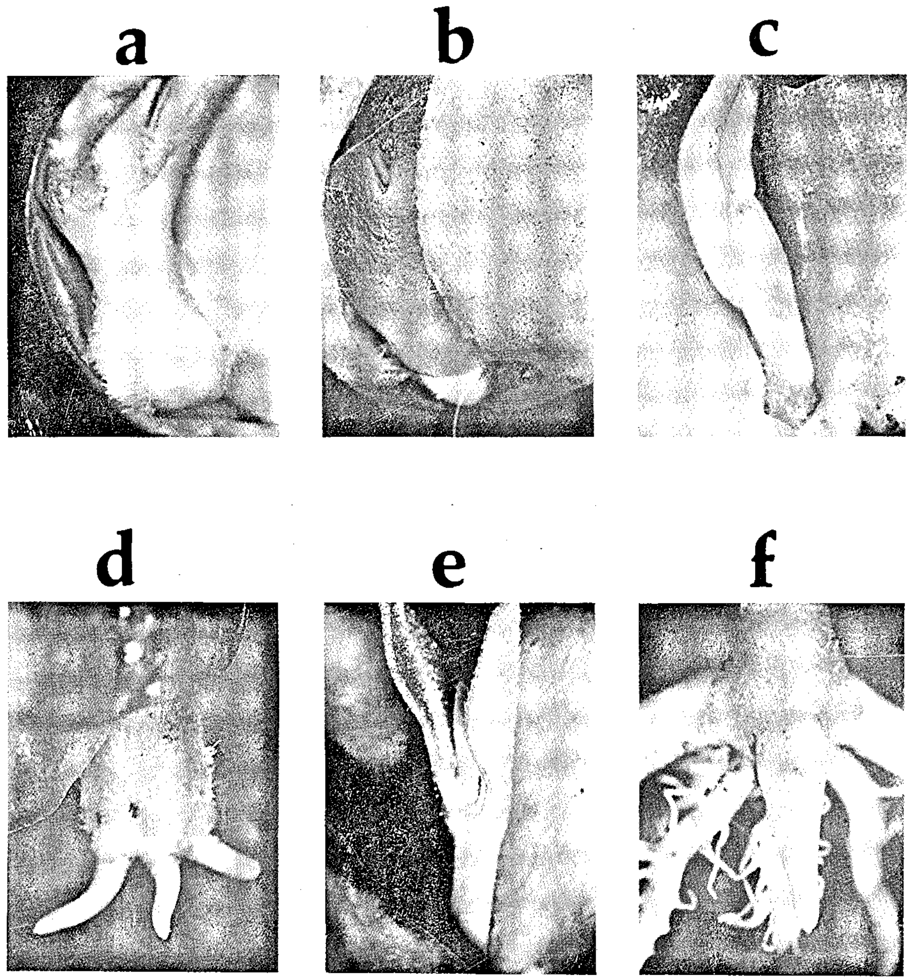

Plate 1: Features of propagules (a,b,c) and of the early germination stages of *Avicennia* seedlings (d,e,f).

Successful germination of propagules is considered upon unfolding of the first two leaves. The subsequent seedling establishment is considered successful when individuals enter the six leaves stage, while those which shed their dry cotyledons and survive to the end of 18th week are considered mature seedlings (immature plants). The individuals growing under lower radiation intensity (LRI) exhibit, on the average, higher survivorship (ratio of survivals to the initial number of propagules) at the different developmental stages compared to the individuals growing under high radiation intensity (HRI) of the experiment (Table 1). The unsoaked propagules growing under LRI on peatmoss substrate attain the highest survivorship (0.87) compared to all other treatments. It is also notable that propagules growing on soil substrate with salinity of about 50% sea water level attain much higher survivorship when growing under HRI (2.5 folds) compared to those growing under LRI.

Table 1

Survivorship (ratio of survivals to total number of propagules) of different development phases in the different treatments under both low (LRI) and high (HRI) rediation intensities.

Developmental Stage	LRI			HRI		
	A	B	C	A	B	C
Total number of propagules	15	70	115	60	80	45
Germination	0.60	1.00	0.97	0.58	0.94	0.91
Seedlings	0.47	0.87	0.89	0.55	0.69	0.84
Immature plants	0.20	0.87	0.71	0.50	0.36	0.82

(A=soil bed and 50% sea water, B=peatmoss and fresh water with no pretreatment, C=peatmoss and fresh water with presoaking of seeds).

Individuals growing on soil substrates and salinity of 50% sea water subject to LRI attained the lowest biomass measures (about two thirds of those in the other treatments), associated with higher root to shoot ratios, higher ash content, and specific leaf area (SLA) compared to indiviuals growing under the other treatments (Table 2). The presoaked propagules produced individuals with higher values of root ratio, ash content, SLA and leaf area ratio (LAR) compared to the untreated propagules grown on peatmoss substrate under LRI; the greatest effects are those on the root ratio and SLA. Conversely, propagules growing on soil substrates under HRI attained a biomass at least twice as high as that of those grown under the other treatments; this is associated with the highest values of all measurements (Table 3). This is particularly clear for the ash content (1.5. fold) and for LAR.

Table 2

Variation in plant characteristics growing in different treatments under low radiation intensity (treatments are similar to those in table 1).

Measure/individual	Treatment			Average
	A	B	C	
Biomass (g)				
Leaves fresh	1.62	2.55	2.30	2.16
Leaves dry	0.41	0.78	0.69	0.63
Total fresh	3.75	5.18	5.32	4.75
Total dry	1.01	1.66	1.51	1.39
Root/Total (%DM)	27.8	14.2	22.5	21.5
Ash content (%DM)				
Leaves	16.0	12.0	13.5	13.8
Stem* Root	15.3	9.2	11.0	11.8
Total (%DM)	15.6	10.5	12.1	12.7
& mg g^{-1}DM)	157.2	174.3	182.1	176.7
No. of leaves	11.3	9.1	11.8	10.7
SLA* ($cm^2 g^{-1}$DM	86.4	73.8	82.6	80.9
Leaf area (cm^2)	35.6	57.2	56.9	49.9
LAR* ($cm^2 g^{-1}$DM)	35.3	34.5	37.8	35.9
RGR* ($mg\, g^{-1} d^{-1}$)	7.4	17.3	14.9	13.2

* Refer to text for indentification.

There is no differences in the performance of presoaked and untreated propagules grown on peatmoss substrate under HRI as well as those grown under LRI. However, these attained much lower biomass, lower ash contents, and higher root ratios, and SLA under HRI. The average initial weight of propagules (excluding pericarp) is about 0.88 gDM, while the average weight of senesced cotylydons during the experiment is about 0.31 gDM.

Accordingly, an amount of about 0.52 gDM per propagule is assumed to be the initial biomass of the individuals. Relative growth rates (RGR) were calculated by divideing the accumulated biomass (above the initial weight) by the growth period (127 days) times the initial biomass. It is obvious that RGR is a direct estimate of biomass attained in each treatment. However, it indicates the extent of variability on compairing the growth under LRI with that under

Table 3

Variation in plant characteristics growing in different treatments under high radiation intensity (treatments are similar to those in table 1).

Measure/individual	Treatment			Average
	A	B	C	
Biomass (g)				
Leaves fresh	2.60	0.93	0.80	1.45
Leaves dry	0.61	0.27	0.23	0.37
Total fresh	5.41	2.34	2.04	3.26
Total dry	1.37	0.63	0.54	0.85
Root/Total (%DM)	29.0	25.8	24.7	26.5
Ash content (%DM)				
Leaves	16.3	10.4	10.4	12.4
Stem* Root	15.7	9.0	9.1	11.3
Total (%DM)	16.0	9.6	9.5	11.7
& mg g^{-1}DM)	219.2	60.9	51.6	99.3
No. of leaves	12.7	7.8	6.2	8.9
SLA* (cm^2 g^{-1}DM	110.1	85.9	89.3	92.1
Leaf area (cm^2)	62.1	23.5	20.1	35.2
LAR* (cm^2 g^{-1}DM)	45.3	37.0	37.0	39.2
RGR* (mg g^{-1} d^{-1})	12.9	1.7	0.4	5.0

* Refer to text for indentification.

HRI in the different treatments (Plate 2). Consequently, growth on soil substrate and under high salinity is much more enhanced under HRI in contrast to the growth on peatmoss under low salinity.

The average ash content per propagule is estimated as about 5.65% DM. Therefore, the average mineral content in a propagule is about 47 mg g^{-1}DM. If this value is compared to those of immature plants in each treatment,it becomes obvious that the highest mineral uptake is attained when propagules are grown on soil substrate under HRI (more than 4.5 fold the initial content in a propagule), followed by those gôrwing on peatmoss substrates under LRI (at least 3.7 fold the initial content). When the latter treatmeant is subject to HRI, the mineral uptake is greatly reduced to very low levels, close to the initial minerals content in the propagule.

The SLA of immature plants does not show much variabiliity over a range of variability in individuals biomass, while it is more affected by root ratio (Figure 1). It seems that lower root ratios are associated with lower values of SLA, and both increase proprtionally up to a root ratio of about 25%, after which the SLA values are maintained within a constant range of variability.

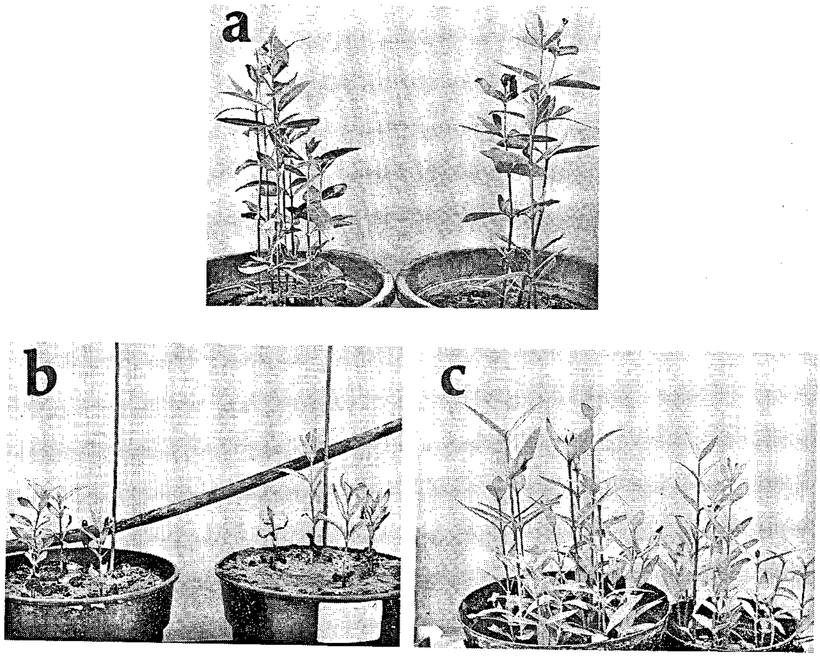

Plate 2: Comparison between the growth of mature seedling under low radiation intensity and low salinity (a), and under high radiation intensity and high salinity on peatmoss bed (b), and on soil bed (c).

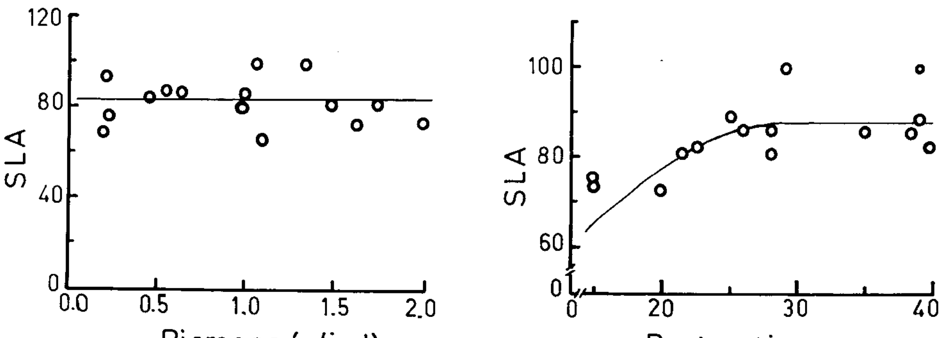

Fig. 1: Relationship between specific leaf area (SLA cm^2 g^{-1}DM) and each of total individual biomass and root ratio (% of total biomas).

DISCUSSION

The ultrastructural, biochemical and germination studies on *A. marina* support the suggestion that germaination type changes are initiated on, or shortly after, the release of the propagules from the parent plant (Berjak *et al.*, 1984, Parmenter *et al.*, 1984), which gives rise to an enhanced rate of germination of the propagules under favourable conditions (Farrant *et al.*, 1985). Experimentation with propagules in the present study shows that the intensity of light radiation (inclination of the sun) affects the survivorship of immature plants together with their growth parameters and resourse allocation to the different organs. The higher radiation intensity "HRI" imposes lower survivorship (average 0.52) compared to that under lower radiation intensity "LRI" (average 0.73). It seems that propagules growing on soil substrate with salinity of 50% sea water need HRI (higher survivorship 0.5 compared to 0.2 at LRI). On the other hand, propagules growing on substrates rich in organic matter content and with much less salinity (average 15% sea water) favour LRI. However, considerable variations occur among propagules growing under each light intentsity depending on the substrate conditions and the pretreatment of propagules. The highest survivorship is attained for the untreated propagules growing on peatmoss bed with low salinity under LRI (0.87).

Kriedmann (1986) states that growth is largely a function of the area and activity of photosynthetic tissues with rates of leaf growth often being the major determinant of plant productivity. It is evident that individuals growing under LRI are characterized by higher average biomass and ash content associated with lower root ratio compared to those growing under HRI. Consequently, a larger number and total area of leaves are produced under LRI and are associated with lower values of SLA and LAR. Therefore, the highest relative growth rates are attained for individuals growing on peatmoss substrate and low salinity under LRI; these rates are at least 15 fold their values for similar treatments under HRI.

The results show that, on the population level of immature individuals, SLA is not a function of total individual biomass. Instead, it exhibits a trend of increase in relation to increasing the root ratio. The Root to shoot ratio in . *A. marina* is known to increase with increasing salinity at the expense of both height and leaf growth (Ball 1988a). Hence the increase in SLA in the present study with increasing salinity is expected and is associated with increasing LAR. However, further impact is imposed on both SLA and LAR together with those of biomass and mineral uptake as a result of growth under different radiation intensities.

Individuals growing under HRI on soil substrates, although have as low as 0.5 survivorship, have the highest SLA (101.2 cm^2 g^{-1}DM), LAR (45.4 cm^2 g^{-1}DM) and ash content (16% DM) compared to the other treaments. Otherwise, growth under HRI is much reduced compared to that under LRI. This contrasts the findings of Ball (1988a) who stated that the growth rates of mature seedlings of *A. marina* declined with increasing salinity, due to the increase in LAR and photosynthesis assimilation rate. Such influence of salinity seems to be effective only at low radiation intensity level; this reveals the limportance of light intensity on the growth of *A. marina* seedlings. This is more evident on comparing the relative growth rates (RGR) of individuals growing under the different treatments, where enhanced growth (RGR=12.87 mg $g^{-1}d^{-1}$) is attained when growing on soil substrates, with higher salinity, under HRI rather than under LRI.

CONCLUSIONS

Interaction among salinity and radiation intensity exhibits a determinant role on growth of *A. marina* seedlings with a higher growth attained under proportional levels of both variables.

The germination on soil substrates underneath the canopy of mother trees is apparently reduced dut to the reduction in the radiation intensity, which requires lower soil salinity levels. This would reflect the importance of the level of photosynthetic active radiation required for growth uner relatively higher salinity conditions, which is attained when growing in the open.

The seedlings growing under high radiation intensity require more water uptake (large LAR), which increases carbon allocation to roots at the expense of its allocation to leaves (higher SLA).

Further research is needed to test the effect of applying salinity stress on mature seedlings produced, in order to determine the germination treament to be selected for transplantation.

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نحو استزراع المنجروف المحلي (القرم *Avicennia marina*) والذي ينمو على الساحل القطري للخليج العربي
١ - الأداء البيئي - الفسيولوجي للبادرات .

محمد سعد الدين عبد الرازق

جمعت عينة عشوائية من الوحدات التكاثرية لأشجار متوسطة الحجم من نبات القرم والذي ينمو بمنطقة الذخيرة بقطر . قسمت هذه العينة إلى مجموعات لإستخدامها في دراسة تأثير كل من شدة الإشعاع الشمسي ومستوى الملوحة ومعاملة الوحدات التكاثرية بغسلها بالماء العذب قبل تنميتها ، على نسبة بقاء ونمو البادرات .

أوضحت الدراسة أن زيادة شدة الإشعاع تؤدي بشكل عام إلى إنخفاض نسبة حيوية البادرات عنها تحت قوة إشعاع أقل شدة ، حيث سجلت أعلى نسبة بقاء للبادرات التي تنمو تحت مستويات منخفضة من شدة الإشعاع ومن الملوحة . إلا أن نسبة حيوية البادرات على الوسط الأكثر ملوحة كانت مرتفعة عند نموها تحت قوة إشعاع مرتفعة ، وصاحب ذلك تقديرات عالية لخصائص النمو بالمقارنة بمثيلتها تحت قوة إشعاع منخفضة .

وقد تميز نمو البادرات على وسط أقل ملوحة وتحت شدة الإشعاع المنخفضة بقيم مرتفعة لكل من قياسات الوزن الحي والمحتوى من العناصر المعدنية ، وصاحب ذلك قيم منخفضة لنسبة الجذر من الوزن الكلي ، والذي نتج عنها عدد أكبر من الأوراق ومن مساحة سطحها الكلية مصحوباً بنقص قيم المساحة النوعية للأوراق . وبذلك فقد تميزت هذه المعاملة بأقصى قيمة لمعدل النمو النسبي للبادرات .

وقد إستخلصت الدراسة أن لكل من قوة الإشعاع الشمسي ومستوى الملوحة تأثيرات واضحة على نمو البادرات ، وأن إدماج العاملين بدرجة متوازنة عند إستزراع البادرات ينتج عنه أعلى نسب لبقائها ونموها . غير أن نمو البادرات تحت شدة إشعاع منخفضة وعند مستوياتها ملوحة أقل ، والتي أدت إلى أقصى نسبة بقاء بالمقارنة بالمعاملات الأخرى ، يحتاج إلى مزيد من الدراسة للتعرف على تأثير التقسية الملحية على البادرات قبل إستزراعها في مواقعها الطبيعية .