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ECOLOGICAL STUDY ON *Plantago major* L. IN THE DIFFERENT HABITATS OF DAMIETTA

Serag, M.M.S.; Amina Z. Abo El-Naga and Mahitab M.A. El-Ramal
Botany Department, Faculty of Science at Damietta, Mansoura University Branch at New Damietta, P.O. Box 34517 (54), Egypt.
***Correspondence Author, Mobile: 0103489609,**
Email: mserag@mans.edu.eg. Serag_1999@yahoo.com

ABSTRACT

A survey was made to study the pattern of *Plantago major* distribution; floristic composition; role of its habitats characteristics on phenotypic plasticity at Damietta, Egypt. Twenty stands were selected to cover seven habitat types. These habitats were namely: sandy fertile cultivated lands, irrigation canals, orchards, reclaimed lands, waste lands, public gardens, and road sides. *Plantago major* was found to be associated with 24 species (14 annuals and 10 perennials) belonging to 23 genera and related to 11 families. The majority of the recorded species are therophytes (65%). The geophyte life form was the most distributed, it occupied 17 sites of the study area. *Plantago major* had a wide ecological amplitude, it was recorded in soils with wide range of moisture content (5.54:37%); salinity (153.2:549.05 μmhos/cm) and nutrients e.g sulphates (0.106:0.584%); calcium carbonates (4.4:20.5%); Ca^{++}(3.6:11.2 mg/g dry wt) and phosphorus (3.65:23.5 mg/g dry wt). This high amplitude forced *Plantago major* to show a considerable morphological plasticity; variation in biomass and water content. There was a correlation among studied traits, indicating a high degree of phenotypic characters. The major soil variables affect the phenotypic plasticity of *Plantago major* were moisture content, soil salinity, sulphates, calcium carbonates, Ca^{++}, and phosphorus.

INTRODUCTION

Phenotypic plasticity is the property of a given genotype to produce different morphological phenotypes in response to different environmental conditions (Schlicting and Pigliucci, 1998, Pigliucci, 2001). Individuals within a species may vary in size, growth rate, allocation to different organs and reproduction (Callaway *et al.,* 2003). Plasticity in morphology should act to increase the performance of the plant (Vretare *et al.,* 2001). In general, species that invest more in roots are thought to competitively dominate habitats with low growth, and those that invest more in shoots are thought to competitively dominate habitats with high growth (Tilman, 1988). Environmental factors were subject to many ecological studies, determining which factors control the presence, number, identity, and relative abundance of plant species remains a central goal in ecology (Jafari *et al.,* 2004).

Plantaginaceae, is a cosmopolitan family being absent only from the Arctic and Antarctic (Parnell, 2003) and comprises of 3 related genera, i.e. *Bougueria* Decne., *Littorella* P. Bergius and *Plantago* L. as well as about 275 species are distributed in diverse habitats throughout the world (Mabberley, 1997). In Egypt, 20 perfect known species and 2 imperfectly known species of *Plantago* were recorded (Boulos, 2002). *Plantago major* is common perennial weed has a wide range of distribution in Nile Delta including Cairo but not further south; Nile Valley; the oases of the Libyan Desert, the Western Mediterranean coastal region including Rosetta stands for Marmarica, and

Sinai (Täckholm, 1974 and Shaltout *et al.,* 2010).

Plantain is the common name applied to a series of ubiquitous herbs (incl. medicinal plants) within the *Plantago* genus. Plantain herb contains 2–6.5% mucilage composed of polysaccharides; 6.5% tannins; iridoid glycosides, including aucubin (Barton, 2007); over 1% silicic acid; phenolic carboxylic acids (protocatechuic acid); flavonoids (apigenin, luteolin); and minerals, including significant zinc and potassium (Meyer-Buchtela, 1999). In Peninsular Malaysia a decoction of the plant is used to alleviate coughs (Parnell, 2003). *Plantago major* was suggested for allergies (Romm, 2004). The aqueous extract of *Plantago major* inhibited *Bacillus subtilis* growth from 21 to 78% and has hematopoietic activity in vitro and is popularly used to treat tumors, infections and as a blood purifier (Lezama *et al.,* 2005). The greatest fame of *Plantago major* as a medicine stems from the use of the leaves as poultice, for every thing from bee stings, to cancer (Duke, 1992).

Due to the high economic potentialities of *Plantago major* in particular the medicinal value, the present study was undertaken to add more information on its associated flora as well as the differences in phenotypic plasticity of *Plantago major* in relation to soil variables at Damietta. This will be useful to the optimal feasibility of the cultivation of *Plantago major* as medicinal plant.

MATERIALS AND METHODS

Damietta Province is a part of the Nile Delta, it located in the downstream part of the Damietta branch of the River Nile at 31º 25' 10" north to 31 º 48' 54" east N-32 º 30' longitude to the north east of the Nile Delta region of Egypt. The total average area of Damietta Province is about 1029 Km^2 and the total agricultural area is about 115892 feddans (Mashaly *et al.,* 2001). Twenty stands (10 x $10m^2$ in area) dominated with *Plantago major* were selected to cover all physiographic variations in Damietta (see Fig 1). The climate of the study area is typically Mediterranean type and belongs to the arid province which is characterized by a short dry period (Ayyad *et al.,* 1983).The annual mean rainfall at Damietta is 102mm. The air temperature varies from 13.3 º C to 27.4 º C with warm summer and mild winter. Relative humidity varies from a minimum of 69 % during summer to a maximum of 84 % during winter.

Five individuals of *Plantago major* were sampled and shoot length, root length, number of leaves, leaf area, blade length and width, spike number and length, as well as number of root fragments were measured according to Montalvo *et al.* (1991), biomass (fresh and dry weight) was determined according to Hickman and Pitelka (1975).

Composite soil samples (0-25 cm) were collected from each stand, air dried, passed through 2 mm sieve. The physical and chemical analyses of soil samples were determined according (Piper, 1947; Jackson, 1962; Hawk *et al.,* 1947 and Palmer & Troeh, 1995).

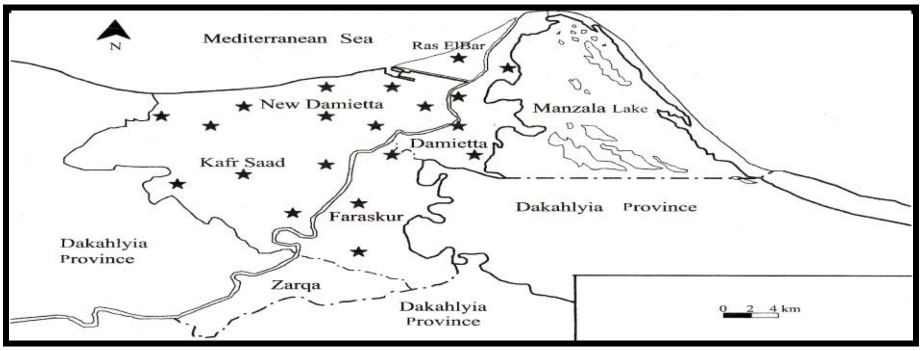

Fig. (1): Location map of Damietta showing the different sites where *Plantago major* and soil samples were collected.

Voucher specimens of wild plants associated with *Plantago major* were collected, identified and deposited in the Herbarium of the Botany Department, Faculty of Science (Damietta), Mansoura University, Egypt. Identification and nomenclature of the plants were following Täckholm (1974) and Bolous (2002 and 2005).

Analysis of variance (ANOVA) was performed by using SPSS program (1999) (version 10). Means were separated according to the Duncan's multiple range tests. LSD was calculated at 5% level of significance According to Kleinbaum *et al.* (1998). Pearson's correlation (r) was performed using SPSS program (version 10).

RESULTS AND DISCUSSION

The eastern section of the Nile Delta including Damietta is rich in its flora on specific generic and families levels (Abu-Ziada *et al,* 2008). *Plantago major* had a wide range of habitats. In this concern Shaltout and Al-Sodany (2008) reported that *Plantgo major* was recorded in Burullus Wetland, it has been found in *Phoenix dactylifera* and *Psidium guajava* orchards in the Nile Delta (Mashaly and Awad, 2003). El-Halawany (2001) recorded *Plantago major* as a common weed in palm orchards in Damietta and Kafr El-Batikh. Shaltout *et al.* (2010) reported *Plantago major* in nine different habitats in the Nile Delta. These habitats are namely: railways; high ways; waste lands; abandoned fields; fields of orchards; fields of summer crops; fields of winter crops; canals and drains. Field study indicated that the study area had seven habitats were namely: sandy fertile cultivated lands, irrigation canals, orchards, reclaimed lands, waste lands, public gardens, and road sides. Sandy fertile cultivated lands were 50 % of the total habitat types, irrigation and orchards 15 %, reclaimed lands 5 % waste land, ornamental gardens and roadsides habitats each resembled 5 % of the habitat types. The total number of the associated plant species growing with *Plantago major* was 24 species belonging to 23 genera and related to 11 families (Table 1), Asteraceae (25 %), Poaceae (16.67 %), Fabaceae (12.5 %), Cyperaceae, Polygonaceae and chenopodiaceae (8.33 %), while Solanaceae, Euphorbiaceae, Verbenaceae and Labiatae (4.17 %). The obtained results were according to Mashaly *et al.* (2008) who reported that Poaceae, Asteraceae, Chenopodiaceae, Fabaceae, Cyperaceae, Polygonaceae, Caryophyllaceae and Cruciferae contribute collectively about 64.61% of the total recorded species of the Deltaic Mediterranean coastal area.

According to the duration or life-span, the weed flora recorded can be classified into 14 annuals (58.33 %) and 10 perennials (41.67 %), the predominance of life-span in the study area is related to annual species. Similar results were obtained by Zahran *et al.* (1990) and Mashaly *et al.* (2002). The majority of the recorded species were therophytes (54.1%), chamaephytes (16.7%), geophytes-helophytes (12.5%), helophytes, geophytes, phanerophytes and hemicryptophytes each was (4.2%).

The Mediterranean climate was designated as a therophyte climate (Raunkiaer, 1937) because of the high percentage (> 50 % of the total species) of this life form in several Mediterranean floras (Raven, 1971). In the present study, the life-form spectrum is predominantly therophytes. The dominance of therophytes among the weed flora was probably attributed to their short life cycle that enables them to resist the instability of the cultivation system of the orchards (Mashaly and Awad, 2003). El-Halawany, (2001) found low percentage of hemicryptophytes and geophytes in cultivated farms and this is similar to the results of the present study.

The geophyte life form was the most distributed, it occupied 17 sites with only one species (*Cynodon dactylon*) this agrees with Mashaly and Awad (2003) who reported the association of *Cyperus rotundus, Chenopodium murale, Rumex dentatus, Solanum nigrum, Sonchus oleraceus Amaranthus lividus Conyza aegyptiaca, Emex spinosa, Euphorbia peplus, Trifolium resupinatum, Dactyloctenium aegyptium, Meliotus indicus, Lotus glaber, Beta vulgaris and Cyperus alopecuroides* with *Plantago major* in *Phoenix dactylifra* and *Psidium guajava* orchards.

The floristic analysis of the study area revealed that the vegetation is typically Mediterranean (41.6%). These taxa are either Pluriregional (25%); Biregional (12.5%) or Monoregional (4.17%), while Cosmopolitan taxa (25%), Pantropical (20.8%), Palaeotropical, Neotropical and Sudano-Zambezian each (4.17%) (Table 1). The Mediterranean element is represented by (55.38). The presence of neotropical, Saharo-Sindian and Sudano-Zambezian elements reflecting their capability to penetrate the study area which may be due to the human activities and agriculture history of the region (Mashaly and Awad, 2003). Similar results had been obtained by Serag (1986); El-Demerdash *et al.* (1990); Mashaly (2001) and Mashaly *et al.* (2003).

Five soil types were recognized in the study area. Sandy soil (60%); sandy clay loam and sandy loam soil (15%); loamy sand and sand clay soil 5%. Biomass and water relations of *Plantago major* showed high variation (Table 2), according to ANOVA results showed in (Table 4) shoot fresh and shoot dry weight had high significant difference at $P< 0.001$. But root moisture content had significant difference at $P< 0.01$ while shoot moisture content had low significant difference at $P < 0.05$. Root fresh and dry weight; succulence and proportional allocation to shoot and root had non significant difference. Also most of the morphological traits of *Plantago major* showed high variation in between sites (Table 3).

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ANOVA applied on the morphological traits (Table 4) showed that shoot length, leaf area, blade length and width, number of leaves, spike length had high significant difference at $P< 0.001$, while spike number, succulence and proportional allocation to shoot and root had non significant difference.

Table (4): One – way analysis of variance (ANOVA) of biomass; water content and morphological traits of *Plantago major*. * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$; N.S = None significant.

Trait	F ratio	Probability	Significance Level
Shoot Fresh Weight	13.567	0.000	***
Shoot Dry Weight	6.052	0.000	***
Succulence	1.527	0.128	N.S
Dry Matter Allocation to Shoot %	0.962	0.520	N.S
Shoot Moisture Content	2.083	0.025	*
Root Fresh Weight	1.336	0.216	N.S
Root Dry Weight	1.470	0.150	N.S
Root Moisture Content	2.931	0.002	**
Dry Matter Allocation to Root %	0.962	0.520	N.S
Shoot Length (cm)	3.718	0.000	***
Root Length (cm)	5.288	0.000	***
Leaf Area (cm^2)	7.469	0.000	***
Blade Length (Cm)	6.242	0.000	***
Blade Width (cm)	5.192	0.000	***
Number of Leaves	5.136	0.000	***
Spike Number	1.778	0.062	N.S
Spike Length (cm)	3.628	0.000	***

Pearson's correlation (r) in (Table 5) showed high correlation between most of the morphological traits; biomass and water relations of *Plantago major*, only root length and succulence did not show any significant correlation with any other trait, this high correlation among traits, indicating a high degree of phenotypic integration (Shemesh *et al.,* 2010).

Table (6) showed that only the edaphic variables related to soil texture had significant correlation with most edaphic variables studied, sand fraction was negatively correlated with silt, clay fractions, and moisture content %, water holding capacity, calcium carbonates %, Na^+, K^+ and conductivity. Silt fraction had a positive significant correlation with clay fraction, water moisture content, water holding capacity, calcium carbonates, conductivity, Na^+, K^+ and Ca^{++}. Clay fraction had a positive correlation with water holding capacity, calcium carbonates %, Na^+ and K^+. Moisture content had a positive correlation with calcium carbonate % and a negative correlation with soil pH. Water holding capacity correlated positively with K^+. Soil pH correlated negatively with sulphates % at 0.05 level. Conductivity was correlated positively with calcium carbonates %, chlorides %, and Na^+. Chlorides had a significant correlation with sulphates %. Calcium carbonates correlated positively with Na^+ and K^+. Na^+ had a positive correlation with total nitrogen and K^+. K^+ had a positive correlation with Ca^{++}. Bicarbonates, total phosphorus and organic carbon showed no correlation with any other edaphic characteristics.

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The correlation between edaphic variables and biomass; water relations and morphological traits, in most cases, were not significant. As mentioned in Table (7), root fresh weight was correlated with K^+ (r=.473), shoot length was correlated with soil organic carbon (r=-.520), root length correlated with soil pH (r=.583) and Ca^{++} (r=.495). Root fragments correlated with soil total phosphorus content (r=.675), succulence correlated with soil moisture content (r=.452) and soil pH (r=-.465).

To illustrate the relation between soil variables and biomass; water relations; morphological traits of *Plantago major*, the twenty study sites were divided into 4 groups according to the increasing concentrations of soil chemical composition (Table 8).

Table(8): The mean values of the four groups of soil variables A, B, C and D, N= number of sites of the study area included in each group.

Soil Variables	Group			
	A	B	C	D
Moisture content (%)	5.54 (N=1)	15.9 (N=6)	24.3 (N=7)	37 (N=6)
pH	7.08 (N=5)	7.65 (N=5)	7.8 (N=5)	8 (N=5)
conductivity (µmhos/cm)	153.2 (N=5)	2.55.98 (N=5)	355 (N=5)	579.05 (N=5)
Chlorides (%)	0.01 (N=3)	0.02 (N=5)	0.03 (N= 6)	0.043 (N=6)
Sulphates (%)	0.106 (N=5)	0.322 (N=5)	0.368 (N= 5)	0.584 (n=5)
Bicarbonates (%)	0.22 (N=4)	0.3 (N=6)	0.4 (N= 6)	0.55 (N=4)
Calcium Carbonates (%)	4.4 (N=4)	11.9 (N=4)	16.1 (N=7)	20.5 (N=5)
Organic Carbon (%)	0.73 (N=7)	1.26 (N=5)	1.95 (N=4)	3.83 (N=4)
Na^+ (mg/g dry wt)	7.03 (N=5)	10.65 (N=5)	16.45 (N=5)	27.13 (N=5)
K^+ (mg/g dry wt)	2.06 (N=5)	3.47 (N=5)	5.12 (N=5)	9.77 (N=5)
Ca^{++} (mg/g dry wt)	3.6 (N=5)	4.48 (N=5)	6 (N=5)	11.2 (N=5)
Total Nitrogen (mg/g dry wt)	8.45 (N=5)	10 (N=5)	14 (N=5)	29.14 (N=5)
Total Phosphorus (mg/g dry wt)	3.65 (N=5)	6.26 (N=5)	9.6 (N=5)	23.5 (N=5)

Many studies have examined phenotypic plasticity as individual mode of plant adaptation to environment (Via *et al.,* 1995). Since soil moisture and nutrients vary temporally as well as spatially (Bazzaz, 1996), this aspect of adaptive response may involve dynamic readjustments in root allocation, morphology, and spatial deployment (Larigaurerie and Richards, 1994). In species with intermediate growth, these responses may be expressed continuously through the life of the individual (Winn, 1996).

High soil moisture content stimulated growth of *Plantago major* in group D which had the highest moisture content; almost all morphological traits reached the maximum values under wet soils except root length and dry matter allocation to root see (Fig 2). Moisture availability is a particularly critical aspect of soil environments (Grime, 1994). Plant growth may decrease in dry soils due to tissue dehydration as well as reduced mineral availability (Caldwell, 1994).

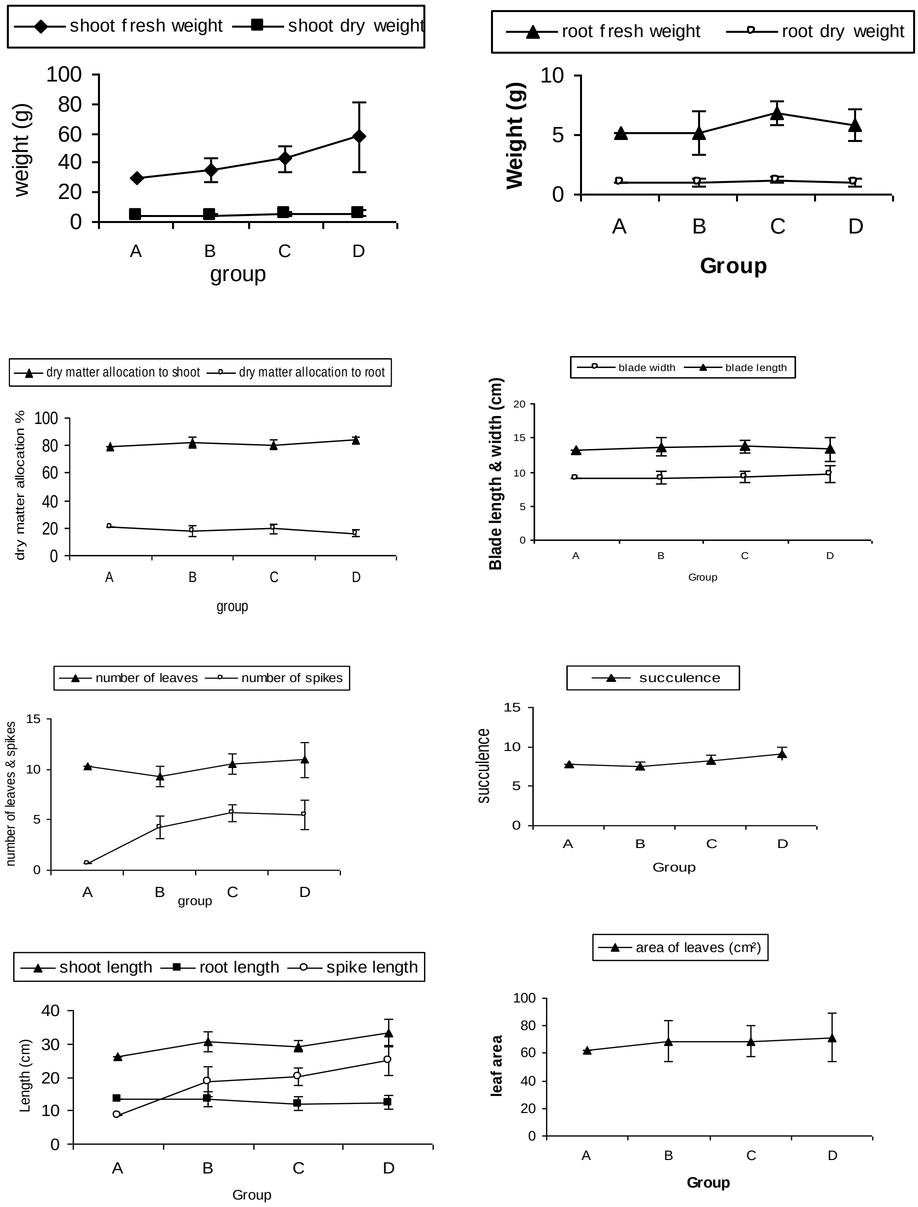

Fig (2): Soil moisture content_ biomass; water content and morphological traits relationship. For each trait means ± SE is shown of each group. Group A=5.54, B=15.9, C= 24.3; D= 37 %.

Plantago major produced the longest root systems in the dry environment in group A and significantly shorter root systems in the moist habitats while produced longest shoots and higher biomass in moist habitats of group D, these changes in absolute root length, reflect on reduced plant biomass in the moist habitats. These results are agreement with Kramer, (1983) who reported that plants subjected to water stress show a general reduction in size and dry matter production, while rapid root extension enables the plants to exploit moisture in dry habitats (Pandey and Thakarar, 1997) and is a valuable adaptation. Shoot moisture content decreased under water stress and this match with results of Mittler *et al.* (2001) and Munns (2002) who found that growth inhibition and decreasing in water content by water stress occurred even in tolerant species.

Plants of *Plantago major* invest more to shoot in case of water availability, while infest more biomass to root in habitats with low water content this means that root biomass proportion (root biomass/ plant biomass) or dry matter allocation to root was highest in dry soil and lowest under moist soil this goes with (Reynolds and Dantonio, 1996 and Bell and Sultan, 1999). It was found that any increase in root allocation of *Plantago major* accompanied with a decrease in the shoot allocation. (Bazzaz *et al.,* 2000) cited that allocation to one function necessarily leads to a decrease in the simultaneous allocation to other functions. In this concern Meier and Leuschner (2008) reported a correlation between soil water content and root biomass; root morphology. Moreover Sultan, (1995) suggested that changes in absolute root length and mass reflect the inevitable growth limits of suboptimal moisture environments, while functionally appropriate changes in proportional traits, such as a decreased ratio of root length and mass to total plant biomass in moist habitats, indicate adaptive plastic adjustment in the context of such limits. This ability to alter root systems so as to maintain function and growth when soil resources are limiting may be a key aspect of individual adaptive plasticity (Grime, 1994). *Plantago major* grown under high moisture content have wider leaves, a note reported also by Zhang (1996).

Mean conductivity gradient of soil supporting *Plantgo major* was high 153.2: 579.05 µmhos/cm; mean chlorides percentage was 0.01 to 0.043%. Mean soil Na^+ ranged between 7.03 and 27.13 (mg/g dry wt) (Table 8). Salinity was found to have adverse effect on the growth rate of plants and consequently their final yield (Pandey *et al.,* 1984).

Salinity has a great effect on biomass; water relations and morphology of the target species; low soil chlorides of group A was the best for increasing fresh and dry weight, shoot and root length, spike length, number of leaves, blade length and width, area of leaves, while decreased with increasing of soil chlorides but all root traits except root length were high with the highest chlorides content in group D (Fig 3).

Shoot moisture content of *Plantago major* at low chloride concentrations was high, but it decreased at higher chloride concentrations, this goes with Khan *et al.* (2000). This brings about an increase in leaf volume or succulence. These responses were similar to the response of dicotyledonous halophytes to moderate salinities (Flowers *et al.,* 1986) and Migahid (2003) who recorded a decrease in water content of non saline habitat species with high salinities.

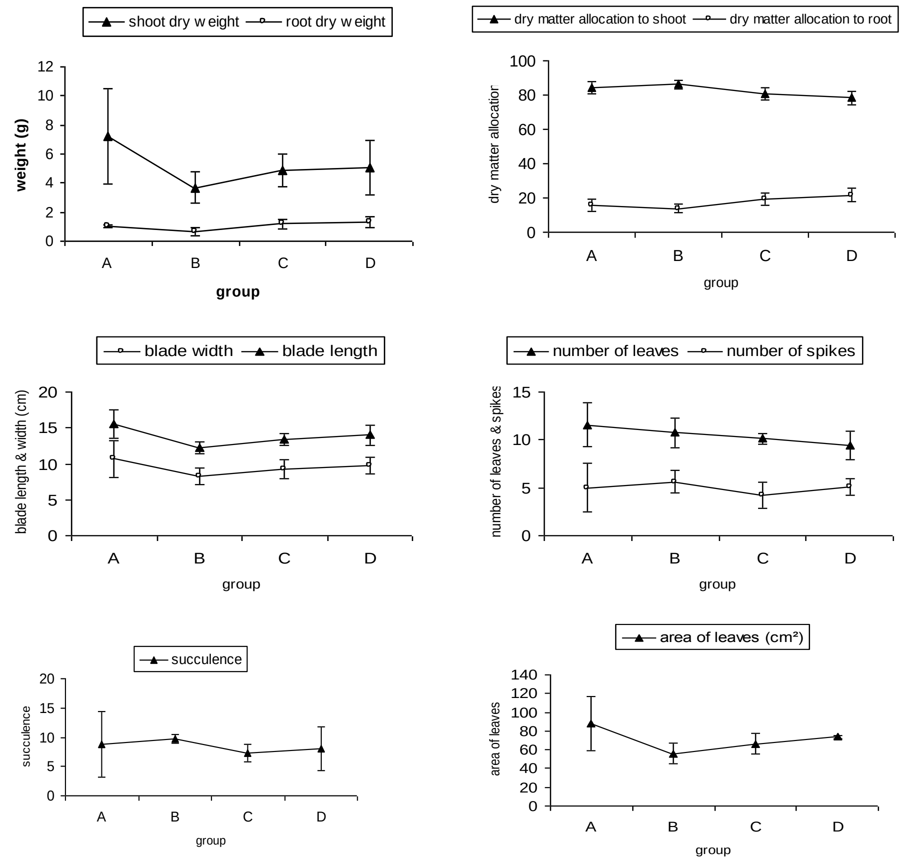

Fig. (3): Soil chlorides _ biomass; water content and morphological traits relationship. For each trait, means ± SE are shown of each group. Group A= 0.01, B= 0.02, C= 0.03, D= 0.043 %.

Succulence is an anatomical adaptation, which by increasing the vacuolar volume, permits the accumulation of larger amounts of water (and dissolved ions) in the leaves. In this study, water content represents more than 68% of the total fresh weight, thus *Plantago major* at low external chlorides tends to be succulent in low saline habitats. Soil conductivity was found to cause increase in shoot moisture content and succulence (=12.85) in group B, accompanied with increase of the accumulation of Na^+ (= 20 mg/ g dry wt) in the shoot while at the highest conductivity of group D, succulence decreased (=6.9) accompanied with a decrease in shoot Na^+ (=7 mg/ g dry wt) in this respect Vicente *et al.* (2004) suggested that succulence may be the reason for the presence of relatively high sodium concentrations in the plant leaves that grown in low salt-treatments.

All the morphological traits of *Plantago major* shoots and roots were lower in high chlorides, while growth maintained high at low chlorides. Our results for reduction of shoot growth and leaf area development with increasing salt concentration are in conformity with the finding of Curtis and Lauchli, (1986), who reported that growth of Kenaf (*Hibiscus cannabinus*) under moderate salt stress was affected primarily through a reduction in elongation of stem and leaf area development, while the reduction in shoot length under saline conditions had been observed on maize by Zörb *et al.* (2004) in addition Garg and Gupta (1997) reported that salinity causes reduction leaf area as well as rate of photosynthesis, which together result in reduced crop growth and yield. Also, high concentration of salt tends to slow down or stop root elongation (Kramer, 1983) and causes reduction in root production (Garg and Gupta, 1997). Leaf number of the target species was somewhat smaller in high chlorides than in low chlorides, this showed similarity to data obtained by Smekens and Tienderen (2001).

In this work, high soil salinity suppressed shoot growth more than root growth, this goes with Ramoliya and Pandey (2003), however fewer studies on the effect of soil salinity on root growth have been conducted (Garg and Gupta, 1997).

Soil moisture content was found to stop the effect of high salinities on plant growth especially on shoots. Plants grown in soils with high salinities and high moisture content like site 8, have high shoot growth rather than plants grown in sites with low salinities and low moisture content like site 14.

Reduction of *Plantago major* growth in response to water and salinity stress was similar Ramoliya *et al.* (2004) who reported that low watered plants were similar to salinity stress plants.

In this work, soil total phosphorus showed significant correlation at 0.01 level with root fragments (r=0.675), root fragments appeared only in plants of site 12 which had the highest soil total phosphorus (35.9 mg/g dry weight), it was noted that root total phosphorus decreased at high soil P concentrations (3.49 mg/g dry wt), this limitation in P in roots may stimulates the formation of new root fragments. These results are agreement with Racette *et al.* (1990) who mentioned that decrease of P concentration in root tissues strongly stimulates the formation of root hairs and lateral roots in leguminous trees, rape, spinach, tomato and white lupin.

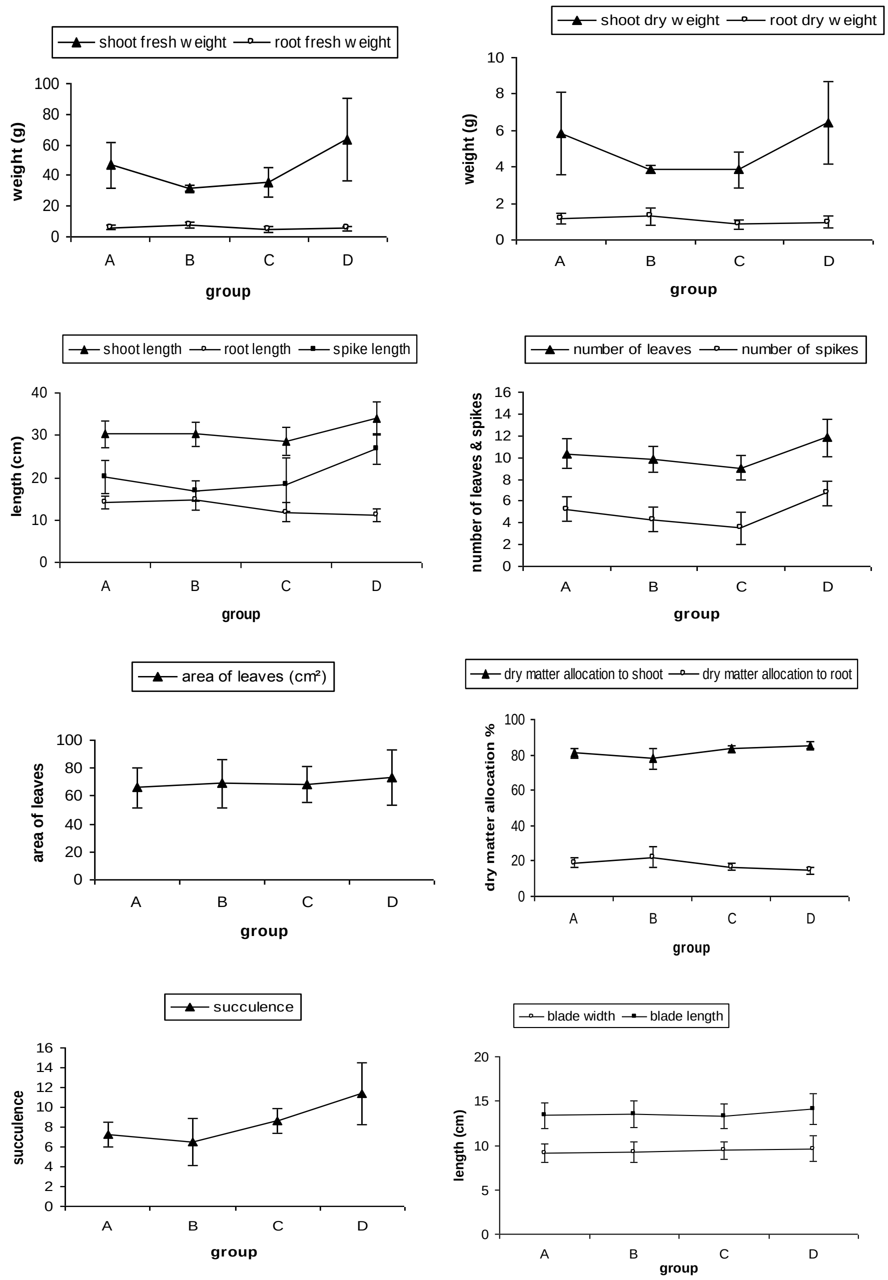

Fig. (4): Soil Sulphat _ biomass; water content and morphological traits relationship. For each trait, means ± SE are shown of each group. Group A= 0.106, B= 0.322, C= 0.368, D= 0.584%.

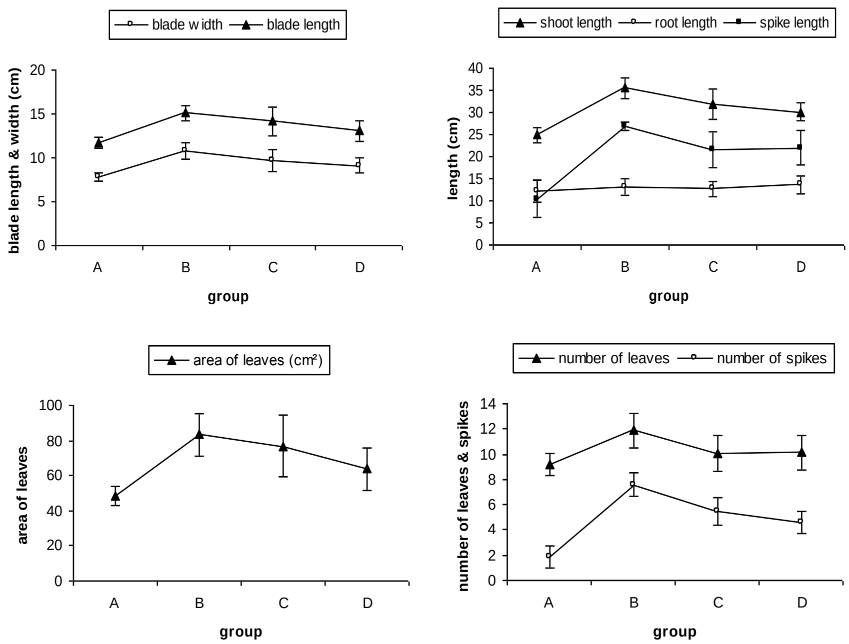

Fig. (5): Soil $CaCO_3$ _ morphological traits relationship. For each trait, means ± SE are shown of each group. Group A= 4.4, B= 11.9, C= 16.1 and D= 20.5%.

Miao and Bazzaz (1990) mentioned that *Plantago major* responded to unpredictable resources by being plastic in growth and biomass allocation which is a major means of plant adjustment to environment. It has been suggested that plants growing in nutrient-poor soil generally develop greater root systems and absorb excess nutrients when they are available (Garnier, 1998 and Poorter and Nagel, 2000) while those growing in nutrient-rich soil allocate proportionally less biomass to roots and more to leaves.

Plants of *Plantago major* maintained at the high nutrient level as high soil sulphates (Fig 4); calcium carbonates (Fig 5) and Ca^{++} (Fig 6) grew significantly to a greater size than did those plants maintained at the low nutrient level in group A which were small, allocating a large proportion of biomass to roots., this agree with the findings of Lehmann and Rebele (2005) in addition, Navas and Garnier (2002) mentioned that low-water plants were very similar to low-nutrient plants and this was true in the present work.

The phenology of flowering of *Plantago major* was influenced by nutrient level. Low nutrient level decreased the spikes production in comparison with plants grown at the high nutrients level like sulphates; calcium carbonates; and Ca^{++}. This goes with data reported by Miao and Bazzaz (1990).

Decrease in leaf area with decreasing soil resources has already been documented by de Kroon and Knops, (1990). In the present study plants which received the lower soil resources as: sulphates; calcium carbonates;

and Ca^{++} were found to have the smallest leaf area. Navas and Garnier (2002) found evidence for effect of water and nutrients availability on morphological plasticity of whole plant and leaf traits.

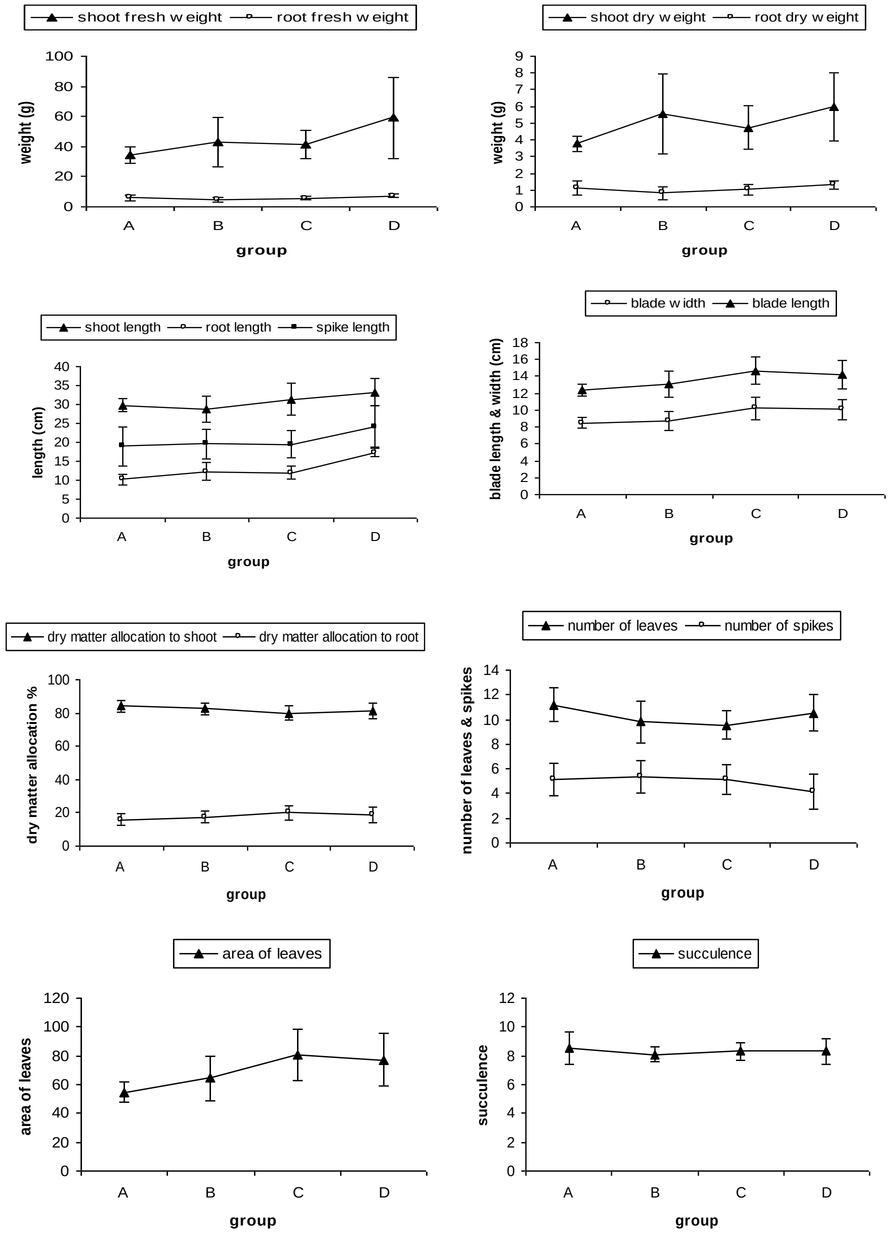

Fig. (6): Soil calcium ion _ biomass; water content and morphological traits relationship. For each trait, means ± SE are shown of each group. Group A=3.6, B=4.48, C=6, D=11.2 (mg/g dry soil)

Number of leaves of *Plantago major* increased in high levels of soil moisture content; in fertile, productive environments, the ability to allocate soil resources to leaf production is characteristic of highly competitive species (Ryser and Notz, 1996). This indicated that *Plantago major* is a competitive species. From the other hand, proportional biomass allocation does not precisely characterize resource deployment (Fitter and Setters, 1988), it does not exactly signify competitive between plant parts but plasticity in biomass allocation patterns and morphology should act to increase the performance of the plant (Vretare *et al.,* 2001).

In this study the plasticity of morphology and biomass in relation to soil variables indicated that plants of *Plantago major* are able to perceive and respond to dynamic environmental changes Shemesh *et al*. (2010) found that this ability might enable plants to increase their performance by responding to both current and anticipated resource availabilities in their immediate proximity.

It can be concluded that morphological parameters provide relatively easily applicable indicators for different environmental conditions, and this will be useful for credible management, and cultivation of this medicinal weed.

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دراسة بيئية على نبات لسان الحمل بالموائل المختلفة بدمياط

ممدوح محمد سالم سراج , أمينة زكريا أبو النجا و ماهيتاب محمود عبده الرمال
قسم النبات – كلية العلوم فرع الجامعة بدمياط – جامعة المنصورة – مصر.

تم عمل مسح بيئي لعشرين موقعا مختلفا بمحافظة دمياط وذلك للوقوف على أهم العوامل البيئية التى تؤثر على توزيع و نمو وكذلك الطراز الظاهري لنبات لسان الحمل. و قد أظهرت الدراسة الحقلية أن نبات لسان الحمل يوجد في سبع بيئات هى: بساتين الفاكهة و الأراضى المنزرعة الخصبة و الأراضى المستصلحة و جوانب قنوات الرى و الصرف و المتنزهات العامة وحواف الطرق. و لقد وجد نبات لسان الحمل مترافقا مع أربعة وعشرون نوعا (عشره نباتات معمرة و أربعة عشر نباتا حوليا) تمثل ٢٣ جنسا تنتمي إلى إحدى عشرة فصيلة. كما وجد أن ٦٥% من النباتات المرافقه هى حشائش برية. و لقد ظهر أن طراز الحياة النباتية geophytes هي الأكثر إنتشارا في سبعه عشر موقعا من مجموع عشرين. و قد وجد أن لنبات لسان الحمل مدى بيئي واسع حيث وجد في بيئات ذات مدى واسع من رطوبة التربة (٥,٥٤:٣٧%) و الملوحة (١٥٣,٢:٥٤٩,٠٥ ملى موز/ سم) و المغذيات مثل الكبريتات (٠,١٠٦:٠,٥٨٤%) و كربونات الكالسيوم (٤,٤:٢٠,٥%) و أيونات الكالسيوم الكلية(٣,٦:١١,٢ ملى جرام/ جرام تربة) و الفسفورالكلى (٣,٦٥:٢٣,٥ ملى جرام/ جرام تربة). و هذا المدى البيئي الواسع أدى إلى مرونة ظاهرية كبيرة و كذلك تنوع في الكتلة الحيوية و المحتوى المائي لنبات لسان الحمل. و قد أظهر التحليل الأحصائى أن هناك ارتباط كبير بين الكتلة الحيوية والمحتوى المائي و الخصائص المورفولوجية لنبات لسان الحمل. وكانت أكثر العوامل تأثيرا على المرونة الظاهرية لنبات لسان الحمل هي رطوبة التربة و الملوحة و الكبريتات و كربونات الكالسيوم و أيونات الكالسيوم الكلية و الفوسفور الكلى بالتربة.

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قام بتحكيم البحث

أ.د / محمود عبد المنعم خفاجي	**كلية الزراعة – جامعة المنصورة**
أ.د / زكريا عوض محمد بقا	**كلية علوم دمياط – جامعة المنصورة**

Table(1): Associated flora with *Plantago major*. Floristic category: COSM: Cosmopolitan, PAN: Pantropical, S-Z: Sudano-Zambezian, SA-SI: Sahro-Sindian, ME: Mediterranean, ER-SR: Euro-Siberian, IR-TR: Irano-Turanian, PAL: Palaeotropical, NEO: Neotropical.

Species	Family	Arabic Name	Life Form	Floristic Category
Perennials				
Pluchea discoridis. (L.)DC	Asteraceae	البرنوف	phanerophyte	S-Z+SA-SI
Symphytrichum squamatum. (spreng.) nesom.	Asteraceae	الأستر	Chamaephytes	NEO
Cynodon dactylon. (L.)pers.	Poaceae	النجيل	Geophytes	PAN
Phragmites australis. (Cav.) Trin. ex steud.	Poaceae	البوص	Geophytes-helophytes	COSM
Echinochloa stagnina. (Retg.) P. Beauv.	Poaceae	الأمشوط	Geophytes-helophytes	PAL
Cyperus rotundus. L.	Cyperaceae	السعد	Geophytes-helophytes	PAN
Cyperus alopecuroides. Rottb.	Cyperaceae	السمار الحلو	Helophytes	PAN
Lotus glaber. Mill.	Fabaceae	رجل العصفور	Hemicryptophytes	ME+ER-SR+IR-TR
Phyla nodiflora. (l.)Green	Verbenaceae	الليبيا	Chamaephytes	PAN
Ocimum foresskaolii. Benth.	Labiatae	الريحان	Chamaephytes	PAN
Annuals				
Sonchus oleraceus L.	Asteraceae	الجعضيض	Therophyte	COSM
Cicorium endivia. L.	Asteraceae	السريس	Therophyte	ME+ IR-TR
Conyza aegyptiaca. (L.) Dryand.	Asteraceae	نشاش الدبان	Therophyte	ME
Xanthium spinosum. L.	Asteraceae	الشبيط	Therophyte	COSM
Dactyloctenium aegyptium. (L.) Wild.	Poaceae	رجل الحرباء	Therophyte	COSM
Emex spinosa. (L.)Campd.	Polygonaceae	ضرس العجوز	Therophyte	ME+SA-SI
Rumex dentatus. L	Polygonaceae	الحميض	Therophyte	ME+IR-TR+ER-SR
Amaranthus lividus. L.	Amaranthaceae	عرف الديك	Therophytes	ME+IR-TR
Chenopodium murale. L.	Chenopodiaceae	الزربيح	Therophytes	COSM
Beta vulgaris. L.	Chenopodiaceae	السلق	Therophytes	ME+ ER-SR + IR-TR
Trifolium resupinatum. L.	Fabaceae	البرسيم البرى	Therophytes	ME+ ER-SR + IR-TR
Meliotus indicus. (L.) All.	Fabaceae	الحندقوق	Therophytes	ME+IR-TR+SA-SI
Solanum nigrum. L.	Solanaceae	عنب الديب	Chamaephytes	COSM
Euphorbia peplus. L.	Euphorbiaceae	اللبينه	Therophytes	ME+ ER-SR + IR-TR

Table (2): Biomass and water content of *Plantago major* shoot and root. According to LSD test means with common letters are not significantly different at *P* ≤ 0.05 level.

Site	Shoot					Root			
	Fresh Weight.(g)	Dry Weight.(g)	Moisture Content%	Dry Matter Allocation %	Succulence	Fresh Weight.(g)	Dry Weight.(g)	Moisture Content%	Dry Matter Allocation %
1	5.65^{b}	0.68^{a}	87.81^{abcdef}	85.98	7.99	0.72	0.11	84.31^{bcd}	14.02
2	36.67^{kot}	3.65^{anrs}	90.05^{cdefo}	87.38	9.38	2.50	0.53	78.93^{abh}	12.62
3	31.67^{bk}	4.28^{aprs}	86.50^{abcd}	81.73	6.80	3.96	0.96	75.82^{a}	18.27
4	39^{kou}	3.46^{akrs}	91.05^{defp}	73.13	9.71	6.88	1.27	79.83^{abj}	26.87
5	165^{a}	13.72^{de}	91.64^{efq}	91.86	11.53	7.23	1.22	83.08^{abcd}	8.14
6	44^{kol}	5.01^{br}	$88.64^{abcdefm}$	83.49	8.54	7.27	0.99	88.71^{cd}	16.51
7	28.77^{bho}	3.57^{alrs}	90.84^{def}	94.26	8.93	5.04	0.22	95.69^{e}	5.74
8	73^{mnq}	9.52^{cd}	86.98^{abcde}	82.80	7.23	10.17	1.98	81.00^{abc}	17.20
9	19.67^{bfo}	2.39^{ahr}	$87.93^{abcdefk}$	74.51	7.76	5.20	0.82	83.98^{abcdp}	25.49
10	52.93^{kq}	4.56^{ars}	91.35^{ef}	77.67	10.14	6.61	1.31	78.08^{abg}	22.33
11	18.47^{bdo}	2.07^{agr}	$89.01^{abcdefn}$	83.46	8.26	2.05	0.41	79.48^{abi}	16.54
12	36.40^{ko}	4.80^{ab}	87.14^{abcdej}	64.10	6.66	13.42	2.69	80.26^{abl}	35.90
13	90.67^{nq}	14.04^{e}	84.84^{ab}	86.76	6.17	9.16	2.14	77.29^{abf}	13.24
14	30.33^{bjo}	3.62^{amrs}	$88.09^{abcdefl}$	79.43	7.80	5.22	0.94	81.71^{abcm}	20.57
15	13.83^{bco}	2.06^{afr}	85.27^{abi}	85.59	6.68	2.26	0.35	83.23^{abcdo}	14.41
16	19.33^{beo}	2.77^{ajr}	85.57^{acb}	89.18	6.72	1.51	0.34	77.22^{ab}	10.82
17	26.33^{bgo}	3.82^{aors}	84.34^{a}	64.37	6.26	10.82	2.12	80.01^{abk}	35.63
18	54.77^{kqr}	6.20^{br}	89.21^{bcdef}	80.67	8.15	7.88	1.49	84.76^{bcdq}	19.33
19	71^{lnq}	7.26^{bcs}	90.04^{cdef}	84.92	9.17	0.72	0.11	84.31^{bcd}	15.08
20	29.75^{bio}	2.42^{air}	91.96^{f}	87.70	12.15	2.50	0.53	78.93^{abh}	12.30

Table (3): Comparisons of the morphological traits of *Plantago major*. According to LSD test means with common letters are not significantly different at $P \leq 0.05$ level. (Data are means of four replications).

Site No.	Shoot Length (cm)	Root Length (cm)	Leaf Area (cm^2)	Blade Length (cm)	Blade Width (cm)	Number of Leaves	Spikes Number	Spike Length (cm)	Root Fragments
1	18.03^{a}	5.1^{a}	28.2^{a}	8.6^{e}	6.3^{a}	5^{a}	1.3	6.8^{ab}	0
2	40.37^{def}	9.5^{abc}	136.0^{gh}	19.4^{ab}	13.8^{hi}	6^{ab}	4	24.2^{bdem}	0
3	30.13^{dcb}	13.9^{cdefgo}	56.4^{abcdo}	13.2d^{efm}	8.3^{abcden}	8^{abcde}	5	26.8^{defghp}	0
4	27.57^{abcl}	13^{cdefg}	48.9^{abc}	12.7^{cfk}	7.6^{abc}	9^{acb}	3	8.6^{ac}	0
5	45.10^{f}	15.1^{defghij}	145.2^{h}	20.2^{a}	14.5^{i}	16^{k}	9.3	40.1^{f}	0
6	28.00^{abcm}	18.1^{ghij}	99.2^{ef}	16.3^{cdp}	11.6^{fghi}	10^{cdefgh}	6.7	25.2^{dhg}	0
7	25.93^{abi}	13.4^{cdefgn}	53.0^{abcdn}	11.8^{efi}	7.8^{abcd}	11^{efghij}	6.5	16.9^{bde}	0
8	41.20^{ef}	10.3^{abcdel}	83.4^{cdef}	15.0^{cdn}	11.1^{efgh}	12.3^{ghijk}	9.3	26.6^{defgho}	0
9	32.30^{bcde}	15.7^{fghij}	49.0^{abcl}	10.8^{ce}	8.6^{abcdef}	7^{acb}	4.5	24.7^{bden}	0
10	33.33^{bcden}	10.5^{bcdef}	79.0^{bcde}	14.6^{cd}	10.6^{defg}	12^{fghij}	7.3	29.0^{efgh}	0
11	27.50^{abc}	10.3^{abcde}	43.8^{ab}	11.72^{def}	7.2^{abk}	7.3^{abcd}	3.7	20.1^{bdek}	0
12	33.40^{bcdeo}	10.8^{bcdefm}	49.6^{abcm}	11.73^{ceh}	8.3^{abcdem}	13^{hijk}	7	18.4^{bdej}	1
13	37.47^{cdefq}	18.1^{hij}	114.2^{fg}	17.5^{bcq}	12.9^{ghi}	15^{jk}	9	25.1^{defgh}	0
14	26.20^{abj}	19.7^{ij}	62.5^{abcd}	13.1^{defl}	9.1^{abcdefo}	10^{cdefgh}	1	8.8^{abi}	0
15	19.60^{ag}	8.8^{abc}	35.9^{ai}	10^{eg}	7.0^{ab}	11^{defgh}	3	13.0^{adb}	0
16	26.30^{abk}	9.9^{abcd}	51.4^{abcd}	12^{defj}	8.2^{abcde}	8^{acdeb}	0	0.0^{a}	0
17	25.53^{abh}	20.1^{j}	43.8^{abk}	11.5^{ef}	7.5^{abl}	9^{bcdefgh}	3.7	16.2^{abde}	0
18	37.13^{cdef}	15.6^{efghij}	85.1^{def}	15.2^{cdo}	10.6^{cdefg}	10^{cdefgh}	3	31.2^{gf}	0
19	34.57^{bcdep}	14.8^{cdefgh}	82.3^{cde}	15.8^{bc}	9.5^{bcdef}	10^{cdefgh}	7	29.1^{hgf}	0
20	25.47^{ab}	5.8^{ab}	36.6^{aj}	10.3^{ef}	7.1^{abj}	15^{jk}	6	20.3^{bdel}	0

Table(5): Pearson's correlation (r) of morphological traits, biomass and water relations of *Plantago major*, SF=Shoot Fresh Wt, SD= Shoot Dry Wt, SM= Shoot Moisture Content, RF= Root Fresh Wt, RD= Root Dry Wt, RM= Root Moisture Content, SL= Shoot Length, RL= Root Length, LA= Leaf Area, BW= Blade Width, BL= Blade Length, NL= Number of Leaves, SN= Spike Number, SL= Spike Length, RF= Root Fragments, S= Succulence, AS= Dry Matter Allocation to Shoot, AR= Dry Matter Allocation to Root. ** Correlation is significant at 0.01 level, * Correlation is significant at the 0.05 level.

	SF	Sd	SM	RF	RD	RM	SL	RL	LA	BW	BL	NL	SN	SL	RF	S	AS	AR
SF	1																	
Sd	.920**	1																
SM	.999**	.902**	1															
RF	.433	.902**	.416	1														
RD	.920**	.544*	.902**	.544*	1													
RM	.416	1**	.395	.946**	.572**	1												
SL	.784**	.770**	.778**	.477*	.770**	.509*	1											
RL	.310	.408	.295	.503*	.408	.465*	.247	1										
LA	.707**	.634**	.708**	.385	.634**	.344	.832**	.325	1									
BW	.773**	.762**	.766**	.290	.762**	.318	.845**	.374	.984**	1								
BL	.788**	.758**	.784**	.292	.758**	.316	.851**	.330	.986**	.960**	1							
NL	.662**	.674**	.654**	.515*	.674**	.426	.372	.147	.314	.309	.334	1						
SN	.668**	.709**	.656**	.589**	.709**	-.490*	.626**	.178	.512*	.514*	.532*	.684**	1					
SL	.707**	.634**	.708**	.385	.634**	.344	.768**	.254	.670**	.675**	.673**	.428	.751	1				
RF	-.053	.521*	-.013	.521*	-.013	.521*	.088	-.117	-.139	-.139	-.110	.189	.169	-.051	1			
S	.359	.054	.389	-.182	.054	-.329	.211	-.273	.273	.265	.223	.288	.238	.354	-.230	1		
AS	.258	.206	.261	-.587**	.206	-.639	.072	-.288	.331	.279	.275	.138	.093	.110	-.525*	.359	1	
AR	-.258	-.206	-.261	.587**	-.206	.639**	-0.72	.288	-.331	-.279	-275	-.138	-.093	-.110	.525*	-.359	-1**	1

Table (6): Pearson's correlation (r) between the different soil variables in the stands surveyed in the study area, M.C = Moisture Content %. W.H.C = Water-Holding Capacity, EC =Electrical Conductivity, O.C = Organic Carbon, T.N = Total Nitrogen, And T.P = Total Phosphorus. ** Correlation is significant at 0.01 level, * Correlation is significant at 0.05 level.

	Sand	Silt	clay	M.C	W.H.C	O.C	Co_3^{--}	$CaCO_3$	CL^-	$SO4^{--}$	T.N	T.P	pH	EC	Na^+	K^+	Ca^{++}
Sand	1																
Silt	-.962**	1															
clay	-993**	.922**	1														
M.C	-.459*	.479*	.442	1													
W.H.C	-.653**	.636**	.639**	.438	1												
O.C	.059	-.035	-.077	.040	.211	1											
Co_3^{--}	-.107	.002	.153	.111	.121	.091	1										
$CaCO_3$	-.620**	.619**	.609**	.474*	.418	-.269	.249	1									
CL^-	.031	.042	-.060	.058	.225	.186	-.181	.123	1								
$SO4^{--}$	-.135	.117	.140	.281	-.096	-.094	-.097	-.002	-.451*	1							
T.N	.378	-.395	-.366	-.228	-.342	.166	-.054	-.421	-.141	.084	1						
T.P	.007	-.002	-.007	-.128	.040	.054	-.227	.014	.172	.072	.175	1					
pH	.023	.001	-.028	-.474*	-.273	-.409	.195	.007	-.026	-.486*	-.11	.045	1				
EC	-.445*	.538*	.396	.300	.410	-.047	-.152	.498*	.455*	-.164	-.132	.075	-.089	1			
Na^+	-.624**	.699**	.580**	.376	.319	-.170	.096	.639**	.238	-.071	.607**	-.298	.206	.455*	1		
K^+	-.768**	.748**	.760**	.401	.456*	-.028	.203	.591**	-.050	.209	.398	-.078	.094	.394	.693**	1	
Ca^{++}	-.440	.481*	.415	.321	.341	.012	.075	.123	.018	-.119	.447*	-.119	.196	-.018	.391	.512*	1

Table (7): Pearson's correlation (r) for edaphic variables; biomass; water relations and morphological traits of *Plantago major* shoot and root, M.C = Moisture Content %. W.H.C = Water-Holding Capacity, EC =Electrical Conductivity, O.C = Organic Carbon, T.N = Total Nitrogen, And T.P = Total Phosphorus, SF=Shoot Fresh Wt, SD= Shoot Dry Wt, SM= Shoot Moisture Content, RF= Root Fresh Wt, RD= Root Dry Wt, RM= Root Moisture Content, SL= Shoot Length, RL= Root Length, LA= Leaf Area, BW= Blade Width, BL= Blade Length, NL= Number of Leaves, SN= Spike Number, SL= Spike Length, RF= Root Fragments, S= Succulence, AS= Dry Matter Allocation to Shoot, AR= Dry Matter Allocation to Root. ** Correlation is significant at 0.01 level, * Correlation is significant at 0.05 level.

	SF	Sd	SM	RF	RD	RM	SL	RL	LA	BW	BL	NL	SN	SL	RF	S	AS	AR
Sand	-.218	-.131	-.226	-.401	-.131	-.213	-.102	-.412	-.191	-.019	-.066	-.146	-.219	-.191	.185	-.191	.219	-.219
Silt	.195	.105	.203	.372	.105	.207	.079	.384	.151	.002	.025	.124	.158	.151	-.149	.158	-.267	.267
clay	.225	.141	.233	.408	.141	.214	.114	.419	.203	.030	.087	.152	.240	.203	-.195	.205	-.196	.196
M.C	.327	.227	.335	.033	.227	-.069	.253	-.267	.343	.14.3	0.46	.227	.312	.343	-.281	.452*	.235	-.235
W.H.C	.073	.072	.073	.130	.072	-.057	-.003	.078	.061	-.100	-.077	.164	.180	.061	-.118	.066	.142	-.142
O.C	-.351	-.382	-.345	-.340	-.382	-.319	-.520*	-.294	-.240	-.414	-.403	-.184	-.320	-.240	-.098	-.075	.000	.000
Co_3^{--}	.016	-.059	.025	-.256	-.059	-.307	-.107	.095	.019	.020	.119	-.394	-.229	.019	-.306	.143	.309	-.309
$CaCO_3$	.105	.029	.113	.377	.029	.205	.170	.085	.304	.102	.091	.058	.305	.304	.139	.340	-.220	.220
CL^-	-.191	.001	-.210	.191	.001	.268	.124	.030	-.093	.051	-.015	-.199	.050	-.093	.221	-.355	-.322	.322
$SO4^{--}$	.016	-.050	.024	-.058	-.059	-.071	.074	-.291	.114	-.047	-.010	.072	.060	.114	-.062	.215	.113	-.113
T.N	-.242	-.239	-.240	-.032	-.239	-.100	-.173	.273	.047	-.094	-.211	-.381	-.166	.047	-.189	-.115	-.200	.200
T.P	-.179	-.180	-.177	.247	-.180	.180	-.042	-.164	-.178	-.281	-.260	.093	-.022	-.178	.675**	-.129	-.244	.244
pH	-.022	.056	-.031	.284	.056	.302	.019	.583**	-.055	.078	.082	-.299	-.132	-.055	.190	-.465*	-.336	.336
EC	.084	.139	.077	.365	.139	.312	.057	.045	-.110	-.062	-.016	.150	.158	-.110	.089	.129	-.264	.264
Na^+	.054	.003	.059	.244	.003	.117	.138	.369	.162	.242	.195	-.162	.100	.162	-.249	.155	-.241	.241
K^+	.093	.100	.092	.473*	.100	.319	.076	.395	.155	.072	.086	.076	.094	.155	-.151	.038	-.267	.267
Ca^{++}	.287	.232	.291	.246	.232	.202	.314	.495*	.300	.242	.176	.058	-.073	.300	-.180	-.041	-.176	.176