

**EFFECT OF DEFOLIATION ON THE
GROWTH, PRODUCTIVITY AND CHEMICAL
COMPOSITION OF SOME RANGE PLANTS
UNDER SALINE CONDITIONS**

**BY
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**DEPARTMENT OF BOTANY
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GROWTH, PRODUCTIVITY AND CHEMICAL COMPOSITION
OF SOME RANGE PLANTS UNDER SALINE CONDITIONS

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PARVEEN AKHTAR

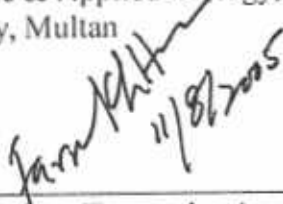
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Parveen Akhtar

Date 14/2/2006 DEPT Botany

Dedication

Sincerely dedicated to my parents

ABSTRACT

In view of the growing need of bringing the saline land into use through cultivation of salinity and defoliation tolerant plants, a study of the effects of salinity and defoliation on the general growth of three grasses, *Bothriochloa pertusa* (L.) A. Camus, *Dichanthium annulatum* Forssk and *Panicum antidotale* Retz. of family Poaceae and one forb *Vicia sativa* Linn. of family Fabaceae was carried out in Laboratory as well as in field at Botany Department, University of Peshawar. Certified seeds of *Bothriochloa pertusa*, *Dichanthium annulatum* and *Panicum antidotale*, obtained from NARC Islamabad and Pakistan Forest Institute, Peshawar, were tested at 0 (control), 5, 10, and 15 dSm⁻¹ of NaCl solutions, for germination and seedling growth in the Phytoecology Lab. of the Department of Botany, University of Peshawar. Germination percentage decreased in *Bothriochloa pertusa*, *Dichanthium annulatum* and *Panicum antidotale* with increasing salinity levels after 96 hours incubation at 25°C. A decrease in lengths of plumules and radicals of all the three grasses was recorded in each treatment. Both fresh weights and dry weights of the seedlings decreased with increasing salinity levels. Moisture contents also decreased with increasing salinity level. In *Vicia sativa* the germination %, radical and plumule growth drastically dwindled under the saline conditions. The effects were more severe in 15 dSm⁻¹, where by the reduction was 5 times in germination, 11 times in

radical growth and 32 times in plumule growth of seedling. The biomass of *Vicia sativa* also decreased due to applied salinity.

The pot experiments were conducted in the lawn cage (net house) of Botany Department University of Peshawar under uniform environmental conditions. The soil used had 8.75% CaCO_3 , 2.6% organic matter, 0.12% nitrogen, 20.9 ppm phosphorus, 413.5 ppm potassium, $1.2 \mu\text{g gm}^{-1}$ copper, $2.2 \mu\text{g gm}^{-1}$ zinc, $3.1 \mu\text{g gm}^{-1}$ iron, $4.0 \mu\text{g gm}^{-1}$ manganese, $200 \mu\text{g gm}^{-1}$ calcium, $305 \mu\text{g gm}^{-1}$ potassium, $216 \mu\text{g gm}^{-1}$ sodium, 7.7 pH level, 0.21 dSm^{-1} electrical conductivity, 0.67% total soluble salts, 27.3% clay, 46.0% silt and 26.7% sand. Ten seedlings each of *Bothriochloa pertusa*, *Dichanthium annulatum* and *Panicum antidotale* from the nursery raised and maintained by the Pakistan Forest Institute were planted in pots and treated by 5, 10, and 15 dSm^{-1} of NaCl solution. Effect of salinity on survival was insignificant. For *Bothriochloa pertusa* the total length (growth) with monthly cutting was the highest in all the three levels of cutting in their respective categories. In *Dichanthium annulatum*, the total growth for 10cm was greater than 5 cm level of cutting and 15 cm level of cutting. For *Panicum antidotale*, the same trend was seen showing the importance of 10cm level of defoliation in *Dichanthium annulatum* and *Panicum antidotale*. As with the monthly cutting the total growths of the plants had increased, the fresh weights also increased.

In *Panicum antidotale* the total fresh weight in the period of three months was greater in M₁ followed by M₂ and M₃. The total fresh weight of *Bothriochloa pertusa* with monthly cutting was the highest at all the three level of cutting in their respective categories. In M₁ category, the growth increased with the increase in the level of cutting from 5cm to 10 cm but then fell at the 15 cm level of cutting. This trend was seen in M₂ and M₃ also showing that 10cm was the best level for defoliation. The dry weights showed the same trend, as did the fresh weights. The dry weights depending on the growth of the plants also increased with the cutting. In *Bothriochloa pertusa*, the dry weight was greater at 10cm level in M₁, M₂ and M₃. The effect of salt was also seen on comparing the M₃ data with the plants in the control groups of each category. The growth in length was higher than the control group and thus the growth in the fresh weight was higher than the control group. With increase in the number of cutting, the root length decreased. The number of tillers in the control groups of the three grasses lowered than the comparative groups at the same level of cutting in many interactions. The number of tillers increased as one goes from M₁ to M₃ in 5cm level of cutting in *Bothriochloa pertusa*. There was significant effect of cutting levels and duration of cutting and salinity on the number of tillers. The data in respect of *Dichanthium annulatum* showed that the number of tillers increased with M₁, M₂ at both 5 and 10 cm. levels but 15 cm level adversely affected the number of tillers. Maximum

number of tiller was found in *Panicum antidotale* at 10cm level in M₂. Overall, no proper trend could be concluded in case of *Dichanthium annulatum*.

Chemical evaluation of samples of treated plants was done. The fresh weights of the roots decreased with the increasing levels of salinity i.e. at 10 dsm⁻¹ and 15dsm⁻¹ levels. The average fresh weights of roots had the same trend. The average dry weights initially decreased at 5-dsm⁻¹ level and then increased at 15dsm⁻¹ level. *Bothriochloa pertusa* (M₃ – 10) plants had more minerals as compared to all other treatments and groups of plants. The M₁-10 plants of *Bothriochloa pertusa* had the greatest carbohydrate contents and greatest energy as compared to all other plants. The M₃ – 10 treatment/group of *Bothriochloa pertusa* had greater nitrogen contents while crude protein was greater in M₁ – 5 plants of *Bothriochloa pertusa*. Ether extract was found more in *Bothriochloa pertusa* in M₂ – 5 as compared to all other treatments and groups of all the plant species while crude fibres were highest in M₂-15 plants in *Dichanthium annulatum*. *Dichanthium annulatum* contained greater %age of moisture contents as compared to the other two grasses and more %age of moisture was found in M₁-15 plants of *Dichanthium annulatum* as compared to all other treatments and groups of all the three plant species. . The seeds of *Vicia sativa* were sown in pots in the month of October and treated with 5, 10, and 15dsm⁻¹ of NaCl solutions with 0 (control). The average survival rate in all the treatment groups was higher than the control groups. On the average, the number of branches

decreased with the increasing level of salinity; the average length at 5 dsm^{-1} was higher than the other two levels in case of *Vicia sativa*. On the average, the fresh weight of *Vicia sativa* at 5 dsm^{-1} was highest than the control as well as other two levels. The average dry weight of *Vicia sativa* also initially decreased at 5-dsm^{-1} levels and then increased at 15dsm^{-1} level. The fresh weights of the roots decreased with the increasing levels of salinity i.e. at 10 dSm^{-1} and 15 dSm^{-1} levels. The average fresh weights of roots had the same trend.

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INTRODUCTION

About one half of the world's people are concentrated on a mere 5% of the earth's surface, whereas 57 % of the land supports only 5% of the people. Pakistan has agricultural based economy. Of the total land area, 60% is classified as rangelands of various categories (Alam, 2002). The rangelands located in the saline habitats support poor agricultural and forage plants. The poor quality and quantity of fodder species in such habitats support low population of livestock, which leads to decreased production of milk, meat and related products. Many fascinating approaches are made for reclaiming and improving such saline soils. However, such methods are expensive due to heavy finances, labour and time constraints. Biological approach is to live with salinity. This involves the identification of salt tolerant species capable of growing and utilizing such habitats. Literature regarding screening and suitability of crop species for saline habitats can be restored in Pakistan and elsewhere. However, no such thorough work has been done on range plants.

Pakistan with an agricultural based economy is the 9th populous country in the world. It has a population of more than 140 millions with an annual increase of over 2.9%. Of the total area of 87.9 million hectares, 33 millions hectares are available for cultivation, whereas only 21 million hectares area is actually cultivated. Another 2 million hectares area is waterlogged. About 5.73 million hectares in Pakistan are salt affected and about 80% of salt affected soils of the Punjab and 56% of those of Pakistan as a whole are saline/ sodic. Pakistan is annually losing nearly one thousand acres of land due to salinity (Hasnain & Sheikh, 1976). The area under

three categories of salt affected soil has been compiled from the reports of the soil survey of Pakistan (Mohammad, 1983). Salt affected soils are estimated to be 4.2 million hectares. Some 26% of the surface area of Pakistan is affected with salinity. Such saline habitats support very poor agriculture and natural vegetation. Salt affected areas also occur in sub humid and humid regions under conditions conducive to their development.

It is estimated that an area of about 6.5 million hectare in Pakistan has different degree of salinity and alkalinity hazards (Alam, 2002). In arid areas like Pakistan water logging is accompanied by salinity (Mohammad, 1983). In N. W. F. P., 0.54 million hectares is saline. It includes areas of Peshawar, Mardan, Bannu, and D.I. Khan (Chaudhry *et al.*, 1978). Soils, which contain sufficient amounts of soluble salts to interfere with the germination and growth of most of the plants is called saline. They are defined as soils, which have electrical conductivity of the saturation extract (EC_e) of 4 or greater than 4dSm^{-1} at 25°C and an ESP of less than 15. Sodium is not the dominant soluble cation in these soils and seldom comprises more than 50% of the soluble cations. Chlorides and sulphates are the principal anions. Saline soils are generally recognized by making a white crust of salt, which has an oily looking damp surface without any vegetation, or sometimes by the stunted growth of crop plants. Based on the climatic maps, the approximate areas of extreme arid, arid and semi-arid regions of the world are 2, 8, 24, 42 and 8.20 million square miles, respectively, i.e. about 36 % of the gross land

area of the world. The worldwide extent of saline and alkali soils is about 322.9 million hectares (Australia 84.7, Africa 69.5, Latin America 59.4, Middle East 53.1, Europe 30.7, Asia and Far East 19.5 and North America 16.0), which is about 26 % of the world's cultivated land. In Pakistan, approximately 6.5 million hectare of land is reported to be affected by salinity that is constantly increasing. It is commonly accepted that under saline conditions, the growth of most of the crop lands is inhibited, because of total ion activity, growth and development of wild halophytes remain either unaffected or is stimulated (Alam, 2002).

The problem of soil salinity/sodicity seriously limits crop growth and production in irrigated areas of arid and semiarid regions of the world where annual precipitation is less than evapotranspiration. Pakistan being part of the arid and semiarid regions is in the severe grip of this calamity. The problem of soil salinity has not only thrown hundreds of thousands of hectare of once productive and fertile land out of cultivation but has also adversely affected the production potential of a large area of irrigated land in Pakistan. Salted soils have different names in different countries. In Pakistan they are called Thor. Calcium chloride and magnesium chloride being hygroscopic absorb atmospheric moisture, keeping the soil surface moist thus making it dark in colour (FAO/UNESCO, 1973). According to the soil salinity classification of Water and Soil Investigation Division (WASID), such soils are

classified into four categories.

Nonsaline soil	0.0-0.2% soluble salts
Slightly Saline	0.2-0.5% soluble salts
Moderately saline	0.5-1.0% soluble salts
Strongly saline	More than 1% soluble salts

The extent of salinity can be observed visibly but for the degree of salinity visual observation is supplemented by laboratory analysis. The salt concentration is determined by measuring the EC and ESP of 1:5 or 1:10 soil to water extract (Asghar *et al.*, 1961).

The salt concentration depends upon several factors, such as the soil texture, type of clay minerals, composition of the salt and the species of plant. A given percentage of salt is more injurious in coarse textured soil than in fine textured soils as the coarse textured soils cannot hold more water and therefore produce more concentrated solution. Persistent high water table and consequent salinity and sodicity are among the major ecological factors rendering more and more soils unfit for conventional agriculture. Such areas however, could be utilized on a sustainable basis for saline forage production and saline forestry (Alam, 2002).

Chemical analysis is a better criterion for assessing the category of problem soil. Sodic soils contain sufficient amount of exchangeable sodium by which the growth of plants is adversely affected. Their pH is between 8.5 and 10 and their EC_e

(electrical conductivity of the saturated extract) is less than 4 dSm^{-1} . Dissolved organic matter present in the soil solution of highly alkaline soil may get deposited on the surface of the soil giving it dark colour. That is why they are called black alkali soils. Their local name is Bara. Russians call it sodic soil with dense subsoil Solonetz. Saline-sodic soils contain both soluble salts and exchangeable sodium ions in sufficient quantity to interfere with the germination and growth of crop plants. Locally they are called Thur Bara. Their pH depends on the dominance of either soluble salts or exchangeable sodium. In the former case the pH will be less than 8.5 and the soil will be permeable. In the later case their pH will be greater than 8.5 and the soils will have low permeability (Mohammad, 1983).

The worldwide, salt affected soils hinder the development of agriculture production. Salinity reduces the overall productivity of crops and plants by inducing numerous abnormal changes in their morphology and biochemical processes (Rabies *et al.*, 1985). These changes could be adaptations, which increase the chances of plants to endure saline stress or damage or disruption of normal equilibrium of life processes

Several options including leaching of salts pumping out sub soil saline water and use of chemicals are available for improving them. Such approaches are, however, expensive in terms of money, labour and time involved. To live with salinity is another approach. Plants tolerant to salinity should be grown. Biological

approach is economical and feasible under the existing conditions. The adverse effects of salinity include delayed and poor germination, reduced root and shoot growth, low productive capacity, decreased regeneration after grazing, shortening of life cycle, high seedling mortality, stunting and feebleness which lead to poor vegetation stands. Delayed germination, high seedling mortality, poor crop stand, stunted growth and lower yield are some common features of plants in the saline habitats.

More than 60% of the total land area of Pakistan could be classified as tropical plains, subtropical, temperate, sub alpine and alpine rangelands. The part of the rangelands in the plains is either arid or saline due to scarcity of rains, high temperature, poor soil leaching and accumulation of salts. Such areas do not support agriculture. Therefore local peoples depend mostly on livestock and their products (Khan, 1973; Noor, 1989).

Livestock play an important role in the economy of a country. Rangelands are vital source of fodder. Aridity and salinity have decreased the quantity and quality of forage species. Overgrazing has declined the over all productivity of palatable species. The average forage production (dry matter) of privately owned ranges is approximately 100 lbs/acre/year with a carrying capacity of 140 acres. In state owned ranges where grazing is somewhat regulated and some pmanagement is observed, the production is 860 lbs/acre/year. In improved rangelands productivity might go to

2700 Lbs/acre/year with a carrying capacity of 51 acre/A.U. The poor range conditions have caused an acute shortage of livestock and their products. The diet of an average Pakistani contains only 12.2 gm animal protein/day compared to an optimum requirement of 68 gm/day (Zahoor, 1988; Balooch, 1987). The per head milk consumption in Pakistan is about 45 kg/year compared to an optimum requirement of 250 kg/year elsewhere. Our livestock are not providing milk and meat according to their capabilities. This decline is due to shortage of forage in the rangelands. The need for fodder and shelter for increasing population demands the use of unproductive salted land. The selection of salt tolerant plants seems to be one of the possible approaches. For this purpose screening of suitable plant species is required. It appears that little studies have been done on the effect of defoliation on the growth and fodder quality of some selected grasses. The present study was, therefore, focused to assess the tolerance and growth behaviour of some grasses (*Bothriochloa pertusa*, *Dichanthium annulatum* and *Panicum antidotale*) and a legume (*Vicia sativa*). The findings might help in utilizing saline habitat of our country. The successful cultivation and growth of these plants will provide fodder for hundreds of starving cattle of our country.

Utilizing saline habitats for the production of fodder crops can enhance the livestock, their health, milk and meat production capacity and soil may also get

reclaimed. The salt tolerance of a crop may be appraised according to following three criteria, as suggested by USDA:

i) The ability of the crop to survive on saline soils; ii) the yield of crop on saline soils; and iii) the relative yield of the crop on saline soil as compared with its yield on non-saline soil under similar growing conditions.

Grazing or defoliation

Physical damages caused by grazing animals include frequently sit, lie, scratch and paw on the pasture in addition to walking, running and jumping on it. The former activities may damage plants, usually in a patchy manner, but are not generally of major significance as the allocation of photosynthetic products (carbohydrate reserves) within grasses is altered with defoliation resulting in the reestablishment of photosynthetic tissues and photosynthetic capacity (Briske, 2004). According to the nutrients diversion theory growth regulators control the supply of photosynthetic products allocated to axillary buds, cell division and cell enlargement in a bud (Mansk, 2005). The pattern of "defoliation" can influence the amount of herbage growth and the amount of harvest. It will be obvious that frequency and level of defoliation may influence crop growth rate by decreasing the capacity of the sward for intercepting light or by exhausting carbohydrate reserves (Speeding, 1971).

During long period of grazing grassland plants develop mechanism to compensate for

defoliation from herbivores, which changes physiology of growth in grasses (Mansk, 2005).

Frequency of cutting often influences yield depending upon how this is measured (for example, dry matter or digestible organic matter) and how it is harvested and what fertilizers are applied. Frequent defoliation usually induces a more poor habit of growth and may greatly change the structure and botanical composition of the sward. It may also retard growth and lengths of roots and thus the weight of roots in the lower layers of the soil. The physiological significance of defoliation is that existing roots may decompose after grazing very rapidly. The effects of grazing or any other form of defoliation on a grass plant are directly related to how grasses grow. These effects depend upon the following:

1. Intensity of defoliation. This refers to how much of the plant remains after defoliation and particularly whether or not the apical meristem is removed.
2. Frequency of defoliation: The number of times a grass plant is defoliated over the growing season is important because it determines how long the plant takes to recover between subsequent defoliations.
3. Season of use: The timing of grazing, corresponding to the growth curve of the grass, influences the response of the plant. Grazing during the dormant season has the least effect because all apical meristems are at the

root crown. Grazing when the apical meristem is elevated, such as at the time of flower initiation, can be most detrimental. Grazing early in the growing season can be detrimental if adequate rests are not scheduled to allow grazed plants to produce new leaves and additional tillers.

4. Growing conditions also influence response to defoliation. Plants withstand defoliation best when soil moisture and fertility are high. Drought or other environmental stresses will decrease the amount of new leaf and tiller production following defoliation, which can hasten plant death.
5. Competition from surrounding plants is important to the recovery potential of defoliated plants. Plants can withstand clipping better and recover faster if neighbouring plants are also defoliated. However, most large herbivores, such as cattle selectively graze grasses, hence, some plants are grazed while others remain ungrazed
6. Grazing resistance or tolerance are general terms used to describe the relative ability of plants to survive defoliation by grazing animals. Strategies to cope with grazing vary. For example, plants with thorns or certain chemical compounds are less likely to be grazed than plants that don't produce these. Most grass plants can be heavily or frequently grazed

but not both. Grasses are usually considered to be the plant group with the highest grazing tolerance

7. Plant stress and even death can result from frequent and intense defoliation. This is due to a combination of reduced leaf area for photosynthesis, the need to initiate new tillers from axillary meristems in order to produce new leaves and reduced plant root growth following defoliation. Increasing degree of defoliation greatly influence, root length and plant form in *Taraxacum officinale*. Holt & Alston (1968) and Hartnett (1989) worked on *Panicum virgatum* and other *Panicum* species. His study showed that these grasses are good for pastures because they show good responses to short-term re-growth.

Saline rangelands can be improved by screening suitable fodder plants for their tolerance to salts. Sowing of grasses in combination with legumes is a useful rangeland improvement technique because legumes fix nitrogen into the soil thus providing a cheap source of nitrogen fertilizer. The crude protein content of legumes is generally 10-15% higher than that of grasses. Thus, common vetch production, which has a place in the traditional crop rotation systems both in irrigated and rain fed areas, is one of the main options to overcome nitrogen fertilizer and feed shortage problems (Mermer *et al.*, 1994). So *Vicia sativa*, a forage legume, was also chosen for this study.

GRASSES

Knowledge of how grasses grow and respond to defoliation is fundamental to most aspects of range management. Typically, grasses are made up of roots, root crown and tillers. A grass plant is really a group of individual tillers that originate from the root crown at the base of the plant. New tillers arise in the axillary buds of older tillers. The new tillers originate at the base of the plant but once they start to grow, each new leaf unit develops from the apical meristem. Apical meristems may remain at the bottom of the tiller, near the ground, or become elevated when the internodes elongate. Reduced root mass decreases the ability of the plant to obtain water and nutrients for growth and survival. Restricted root systems can be especially harmful during times of drought.

The grasses selected for the present study included *Bothriochloa pertusa*, *Dichanthium annulatum* and *Panicum antidotale*, which belong to subfamily Panicoideae of family Poaceae. They are highly esteemed as fodder grasses especially in India, where cattle eagerly eat them. They are fed green, when they are young, also suitable for silage and hay if cut before flowering. They show promise for reseeding degraded grasslands; also used for rough lawns (Cope, 1982). Mature plant withstands repeated cutting, continuous grazing, trampling and withstand drought. Because of their habit to send out rooting shoots, to get established quickly and to grow luxuriantly on a wide range of soils in tropical climates they can develop a successful rangeland they were chosen for this study. (Gohl, 1981), they were chosen for this study.

BOTHRIOCHLOA PERTUSA (L.) A. CAMUS

Pashto name: Kano, English name: Hurricane grass, Seymour grass, Barbados sourgrass, Pitted bluestem, Comageyana. It has different synonyms that are:

Holcus pertusus Linn; *Andropogon pertusus* (L) Willd; *A. angustifolius* Parl;
Amphilophis pertusa (L); *Lepeocercis pertusa* (L) Hassk and *Elionuris pertusus* Nees
 ex Steud.

It is a perennial tufted rhizomatous grass, which occurs on the borders of the lowlands and bunds of cultivated fields (Shankarnaryan, 1984). It grows best on sandy loam soils (Duke, 1981). It grows in dry areas. It is valued by some for pasture, but considered by others a weed. It can withstand heavy grazing and short dry spells. It is used for fodder, hay and mulch. It is said to be low yielding (Gohl, 1981), but yield figures approach 15 MT DM/ha.

Morphology

Stoloniferous perennial grass; culms ascending, branching, sometimes long running, Shooting at the nodes, about 30 cm tall, much taller when cultivated; sheaths rounded; leaf-blades flat; panicle axis shorter than the lower branches, purplish, emitting an aromatic odor when crushed; racemes few to several, first glumes of sessile spikelets always pitted; 10–15 mm long; pedicellate spikelet about as long and broad as the sessile ones (Cope, 1982).

Distribution and Ecology

It is a bunch grass growing from plains up to 1000 meters in dry hot tropical and sub-tropical regions of the world. It grows in regions with 500- 1375 mm rain. It

withstands short dry spells. It is widely distributed in Old World Tropics, from Arabia and Tropical Africa to Southeast Asia, India, Sri Lanka and Indonesia. It is considered one of the better pasture grasses in the West Indies, Uganda and India. It occurs mainly on well-drained soils where rainfall is 500–900 mm, and is common along roadsides and in dry areas. It can withstand moderate periods of drought. It does not tolerate frost.

It can withstand heavy grazing and trampling. It is highly appreciated as a fodder grass and it makes useful hay. It is highly palatable. Satisfactory for lawns, as it sends out numerous creeping shoots which root at the nodes. Although valued by some for pasture, others consider it a weed. It is cultivated mainly in pasture mixtures and seeded along roadside embankments in warmer regions. It germinates quickly and establishes readily. It is preferred for pastures and preventing erosion by range management personnel because of their easy germination, seedling establishment, fast growth and production of enough palatable forage and seeds. The most important characteristics are that it can withstand drought and grazing effectively.

Bothriochloa pertusa is an excellent pasture grass in many tropical areas of the world, as West Indies, East Africa and India, where it is suggested for reseeding degraded grassland. It is grown to some extent in warmer parts of the United States along roadsides. According to the phytomass files (Duke, 1981), annual productivity ranges to 15 MT/ha.

The members of *Bothriochloa* complex are apomictic and freely hybridise with in the genus and also with other genera like *Capillidium* and *Dichanthium* (Farooqi *et al.*, 1989). It has been observed that *Bothriochloa intermedia* and *Dichanthium annulatum* hybridise in India while in Pakistan, hybridisation is common between *B. ischaemum* and *B. intermedia*. The grass prefers comparatively less dry habitat. It grows easily from seed or root cuttings in spring and rainy seasons (Farooq *et al.*, 1989). It flowers early in summer and continues till late winter. It can also withstand grazing and moderate drought.

DICHANTHIUM ANNULATUM FORSSK

Pashto Name: Thala, English Name: Delhi grass Urdu Name: Jarga, Bara, Jergi, Marvel.

Morphology

The plant arise from a decumbent base, nodes pubescent; blades flat, 5-20 cm long, tapering to a fine point, inflorescence of subdigitately arranged racemes, these 3-6, sometimes more [var. *bladhii* (Retz.)], 3-7 cm long; not more than 3 pairs of the lowest spikelets sterile; peduncle of raceme glabrous; sessile and pedicellate spikelets alike, usually overlapping, the pedicels usually in part visible; lower glumes of pedicellate spikelets not armed with marginal bulbous-based bristles; lower glume of sessile spikelet oblong, obtuse or truncate, keel not winged, median vein present; ligule long; upper lemma the hyaline base of the awn (Cope, 1982).

Ranging from subtropical dry to moist through tropical very dry-to-dry forest life zones, Diaz bluestem is reported to tolerate annual precipitation of 7.0 to 26.4 dm (mean of 6 cases = 12.3) annual temperature of 12.5 to 27.5°C (mean of 6 cases = 21.6) and pH of 5.5 to 7.8 (mean of 6 cases = 6.7). It is found naturally in weedy lawns, sand dunes, fallow fields, roadsides, open wasteland, in hedges and pastures; often escaping and becoming weedy. It thrives in sheltered and disturbed areas, neglected areas near crop fields and in grass fields where it tends to be a grass weed. It is adapted to tropical and subtropical summer rainfall areas. It is quite drought-resistant and tolerates seasonal burning. It is preferred for palatability. It is a summer growing, perennial grass, which is 60- 120 cm high. It is found mostly in arid and semi arid zone. It occurs occasionally on rocky ground (Gohl, 1981).

It has an altitude range of 250-1375m in India and Pakistan. It grows well on sandy loam soils, on areas, which receive more than 750mm rain. The range is 500-900 mm. It is a drought resistant variety (Skerman & Riverose, 1990). A good stand of grass yields 1,320 kg hay/acre. It grows commonly throughout the plains and hills of India up to 1660 m; also in tropical and North Africa extending east through Southeast Asia to China, Australia, Fiji and New Guinea. Introduced to West Indies (Cuba, Haiti and Puerto Rico).

Dichanthium annulatum propagates by seeds and underground vegetative parts. Plants are good seed producers but show great variability in their ability to

germinate. Usually the very light seeds are spread by wind, allowing invasion of new areas. Experiments indicate that seeds produced by plants from protected areas give maximum germination of 95.3%, whereas those from shady areas give 84.6% and those from grazed fields, 36%. Seeds with glumes intact give 56.6% germination and those with glumes removed give 94.6%. Due to glume removal, the embryo becomes exposed directly to light and moisture, causing higher germination (Gupta & Yadav, 1986).

Also increased depth of planting of seed lowers the germination percentage. Seed germinates at a temperature range of 15-40°C; optimum temperature for germination being 32°C (up to 78% seeds germinate). Seeds exposed to a sub-freezing temperature of -10°C for 15 days germinate 78.6% at room temperature (27°C $\pm$ 5°). Periodic tillering from the underground rhizome maintains the perennial habit of this grass. It forms open turf under grazing and is cut before flowering, for use as hay and silage.

Dichanthium annulatum is regarded as one of the best pasture grasses in India, Pakistan and Burma, although the crude protein content of herbage is usually low to medium. It is used extensively throughout the range of Southeast Asia and the East Indies. Sometimes used in the West Indies as well, especially for rough lawns. In

India unclipped plots yield 8925 Kg/ha compared with 3225-3570 for clipped plots (Gupta & Yadav, 1986).

The annual productivity of *Dichanthium annulatum* ranges from 7 to 17 MT/ha. Diaz bluestem yields more than 10 MT hay/ha in India and stands cutting well. Duke (1981) reported that depending on soil moisture conditions herbage yield was 2-20 MT/ha; while in a semi-arid area in Cuba it was 17 MT DM/ha (46% of yield from dry season with sprinkler irrigation).

PANICUM ANTIDOTALE RETZ

Pashto Name: Khwarash. English Name: Blue panic grass, Common Name: Malai, Gam, Gunjgomaz, Mort, Gomal, Local Name: Thal-Malai, Cholistan desert-Malai, Gam. Murrot, Bansi ghaa (Cope, 1982).

Morphology

Perennial, with erupting woody rootstock, culms (30) 90-180 cm high, woody, erect or ascending, usually branched, lower internodes often perinose. Branching at the nodes. Flowering stem is up to 2m in high. Leaf blades linear, blue green 6-30 cm long and 5-12 mm wide flat glabrous, sharply pointed ligulae is membranous and 5-2 mm wide.

Inflorescence: Narrowly pyramidal to broadly oblong or ovate 13.32, cm long, varying from copiously branched with the branched sub verticillate sparingly branched with the spikelets condense about the distant branches. Spikelet: Elliptical, 2.4-3.2 (-3.6) mm long, glabrous, acute, lower, glum broadly ovate membrane with broad hyaline margins high to 2 third as long as the spike lets rarely less, 3-5 nerved, acute, upper glum with broad hyaline margins, 7-9 (-11) nerved, lamina 7-9 nerved its palea almost as long; upper lamina pallid, smooth and shining. Seeds are produced in large panicles. The plant is 20-45cm long and 6015 mm wide (Cope, 1982).

In Pakistan it is distributed in Sindh, Balochistan, N.W.F.P., Punjab, and Kashmir and adapted to Thal and Kohistan ranges. Also distributed in Nepal, Sri Lanka, Tropical Africa, Arabia through Iran and Afghanistan to India (Noor, 1989).

Blue panic (sometimes known as giant panic) is a tall, coarse plant with cane-like stems growing to 2.5 metres under good conditions. The leaves are bluish, smooth and rather tough in texture. The plant is very deeply rooted and expands by

short, thick rhizomes; the crown is strongly developed with swollen stem bases. Blue panic is a vigorous summer grower, adapted to the 500-750 mm annual rainfall belt. It is versatile in its soil requirements, growing well on both sandy and black cracking clay soils and has shown promise in the gidgee scrub areas of Queensland. It can be frosted, but produces shoots quite early in the spring and at times when other plants show moisture stress; it is also resistant to fire and to heavy stocking (Humphreys & Partridge, 1995).

Blue panic is composed of flowers, ascending branches, and seeds shatter at maturity so seeds collection is usually difficult. Seed remain dormant for about 1 year (Cope, 1982). It is best suited to fertile sandy loam soil in areas receiving 500-800 mm of precipitation and altitude up to 1000mm. It is sown at the beginning of monsoon. Its seeding rate is 152.5-300 kg/ha. Seedbed is disked and cultivated; drilling is preferred for a uniform stand. In Pakistan, most seed is broadcast. Tuft planting is also common in hilly areas for soil conservation; the seed need to be covered by a thin layer of soil. Germination starts within 8-10 days of sowing. A full season growth is required for plant establishment (Noor, 1989). Grazing is normally allowed in the second year. It is a palatable grass and has bitter taste and accumulates oxalic acid, which can cause kidney disorder. It is self-defensive grass. The stem rapidly becomes hard and woody and injures animals' mouth. Grazing is so restricted to current year growth old stubble and previous growth remains intact year after year.

It should be grazed or cut for hay before flowering because at late flowering stage it accumulates oxalic acid, which causes kidney disorder (Noor, 1989). It is an excellent soil binder, but of doubtful value as fodder. Forage production is significantly increased if nitrogenous fertilizer is applied. A 50% increase in dry forage yield by the application of 100 kg/ha of urea was shown by Mohammad (1983).

Reseeding with blue panic increased range productivity 12 times compared to that of range in the Jamrud areas of North Western Frontier Province (Mohammad, 1983). The optimum seeding rate is 2.5 kg/ha, which gave 1120 kg/ha of seed. Seeding 1 kg/ha produce 1015 kg/ha of dry forage. Seeding 0.5 kg/ha produce 372 kg/ha during first year. Similar, results were obtained in Neelam Valley. Livestock height gain increased substantially in pasture reseeded with blue panic (Mohammad, 1983).

In Kohistan range, blue panic yielded the 2nd largest after buffel grasses. Planting tuft of blue panic is more successful. Potohar range and Murree foothills are highly suitable for large scale seeding. (Noor, 1989). The plant is a disinfectant in smallpox. The smoke is used for fumigating wounds and the drug is used for throat infections. It produces the forage that is exceptionally high in crude proteins, phosphorus and calcium. It has one of the highest proteins and phosphoric acid (81%) contents in warm season grasses grown in Texas. Dry matter 94.6, Crude proteins

15.3, Ether extract 3.4, Crude Fibre 29.3, NFE 41.6, and Moisture 5.3. (Masood *et al.*, 1993).

VICIA SATIVA LINN

Pashto Name: Marghai Khpa,

English Name: Common Vetch, Spring Vetch or Oregon Vetch Common vetch, spring vetch, garden vetch, tare.

Vicia sativa L. was introduced in Rio Grande do Sul (Southern Brazil) by Italian settlers and is nowadays cultivated for forage in backyards and fields. *V. angustifolia* is widespread highly polymorphic. Both taxa grow sympatrically and morphologically transitional types are often found (Weber & Wittmann, 1999).

Morphology

Vicia sativa is a pubescent annual with scrambling and climbing growth habit. Stems arising from the base are hollow, squarish in cross-section and up to 2 m tall. Taproot system is slender with numerous lateral branches. Leaves compound pinnate with 3-8 pairs of opposite leaflets and 2-3 terminal tendrils. Leaflets are narrowly oblong, square at the apex and with a small projecting mid rib. Stipules are small and divided. Inflorescences borne singly or in pairs on short peduncles arising at the base

of the leaves mainly blue to purple but sometimes white and self-fertilized. Seed/pods contain 4-12 round but flattened seeds, mainly black to greyish in colour.

Ecology and Distribution

Vicia sativa is an annual winter growing leguminous plant, which germinates in October. It propagates by seeds. In some colder parts of the world it flowers from April to July while the seeds mature from May to July. This plant is adapted to well drain fertile loam soils and can be grown on well-fertilized sandy soils. It tolerates many soil types (Shankarnaryan, 1984). It requires cool temperature for vegetative growth and seed production. It is native to the near east. Maximum biomass is 8000-9000lb/h. extra floral stipular nectaries feed aphidophagous hover flies. Cowpea aphids attack the plant and are abundant in spring. It contains 4% nitrogen. It has 80% digestibility both in vegetative and hay stage (Gohl, 1981).

Vicia sativa is native to southern Europe. It is utilized as cool-season annual in semi-arid Mediterranean regions with October-April rainfall of 200-400 mm (Papastylianou & Danso, 1989). It also grows in North Africa and continental West and Central Asia and introduced to other temperate countries of the world, e.g. North America for spring and/or autumn sowing depending on climate. It is adapted to a range of soils but acidic and poorly drained soils are avoided. Rapid growth rate sprawling growth form but grows upright when sown with a companion cereal, e.g.

commonly with oats and to a much lesser extent with barley or wheat in Mediterranean area (Caballero *et al.*, 1995).

Vicia sativa seeds are sown mainly in spring. It is either spring- or autumn-sown plant. Some spring cultivars are susceptible to frost but others are cold hardy and can be sown in autumn. It is less cold hardy than hairy vetch and intolerant at early stage of establishment. It prefers well-drained, moderately fertile soils with pH 6.0-7.0. Well-cultivated, uniform and firm seedbed is required for good results. The plants are normally drilled, whether sown pure or in combination with cereals or cereal/forage peas, but can also be broadcast. It can be directly drilled (sod seeded) into warm-season grass swards. It is sown at 3-5 cm with a good soil cover. Sowing time is spring or autumn depending on farming system. In Mediterranean areas, 100-150 kg/ha when sown pure, or 50-150 kg/ha together with 20-70 kg/ha oats when sown in hay mixture, vetch can make up 40-70% of the hay composition in such mixtures. In the UK, vetch is more commonly sown at 10-30 kg/ha in cereal/pea/vetch mixtures for arable silage (Caballero *et al.*, 1995).

In the southern USA, 30-40 kg/ha is used for pure-sown stands and somewhat lower rates when used in mixture with a cereal. Common vetch is suitable in areas with mild winters and often winter kills in the northern parts of cotton belt. The species are moderately resistant to cold but does not grow as rapidly during winter. The tolerating mean temperature is 5.6—22.5° C. *Vicia sativa* is tolerant to several

pre-emergence herbicides, e.g. linuron, prometryn (Caballero *et al.*, 1995). Nitrogen-fixing ability of *Vicia sativa* is high.

It grows vigorously once well established. In northwest Spain autumn-sown stands of *V. sativa* and *V. villosa* averaged 1.90 t/ha DM when harvested in April and 5.18 t/ha in May. In central Spain, 3.12 t/ha DM was obtained from a monoculture harvested at pod-setting stage (Caballero *et al.*, 1995); in the same trial common vetch yielded 1.74-3.21 t/ha in vetch/oat mixtures, with increasing vetch yields as the proportion of oats in the sown mixtures was reduced from 40% to 10%.

In Cyprus vetch yielded 4.5-6.0 t/ha DM when cut at the hay stage (Papastylianou & Danso, 1989); pure-sown vetch did not respond to fertilizer N application but its yield decreased with increasing N application in vetch/oat mixtures while oat contribution increased. A survey of the role of forage legumes in arable cropping systems of the Mediterranean area reported the range of hay yields of common vetch/cereal mixtures as 2 to 6 t/ha (Caballero *et al.*, 1995).

Vicia sativa is utilized for hay or silage, particularly arable silage, in the UK from cereal/vetch or cereal/pea/vetch mixtures. Mixtures of vetch and small grain cereals are grown for haymaking in Mediterranean area (Caballero *et al.*, 1995). Autumn-sown vetch is winter grazed or can be ploughed in as green manure in southern USA

Vicia sativa is a valuable source of protein and minerals. On a DM basis, average values of crude protein (CP) in spring or autumn-sown *Vicia sativa* and *V. villosa* in northwest Spain were 25.1% in April and 17.3% in May; correspondingly, acid detergent fibre (ADF) values were 28.2% and 32.6% (Iglesias & Lloveras, 1998). In central Spain, autumn-sown common vetch harvested at the pod-setting stage had 19.6% CP and 29.6% ADF (Caballero *et al.*, 1995).

At growth stages 30% and 60% DM in pod seeds mean whole plant crude protein content was 19.3% and 16.7%, respectively and digestible dry matter (DDM) 63.4% and 59.1% (Caballero *et al.*, 1995). For common vetch hay production, the maximum nutrient yield is attained when the seeds within the pods have a DM content of 45-55% (Caballero *et al.*, 1996). It is a highly acceptable as grazed or conserved forage. It can be grazed by a range of livestock, including zero grazing (green fodder cut and carried). Grazing is necessary in order to leave the basal axillary buds, which are the regrowth sites. 400 to 1500 kg/ha is obtained in the USA (Miller and Hoveland, 1995) while the number of seeds per kg is 16000 to 20000.

Pests

Miller and Hoveland (1995) listed several pests, which can cause plant damage are pea aphid (*Acyrtosiphon pisum*), corn earworm (*Heliothis zea*), fall armyworm (*Spodoptera frugiperda*) and spider mites (*Tetranychus spp.*).

Main attributes: *It is* a short-term catch crop with a high nutritive value. Protein-rich, highly acceptable feed for different classes of stock. It provides a valuable constituent of vetch/cereal mixtures.

Main shortcomings

Moderate yield and quality ideally requires companion cereal species to avoid lodging and harvesting difficulties, which occur with monocultures

STATEMENT OF THE PROBLEM

The main purpose of the study was to determine the effect of simulated grazing under saline conditions on the survival, growth and productivity of three grasses namely, *Dichanthium annulatum*, *Panicum antidotale* and *Bothriochloa pertusa* and one legume namely, *Vicia sativa*. These plant species were chosen because of their many good qualities mentioned earlier.

Objectives of the study

Objectives of the study included:

1. To see the effects of saline conditions on the germination and seedling growth of *Bothriochloa pertusa*, *Dichanthium annulatum*, *Panicum antidotale* and *Vicia sativa* under laboratory conditions.
2. To see the effects of different levels of salinity on the growth performance in the field using pots.
3. To evaluate fodder species in response to different levels and intensity of grazing (defoliation) under different levels of salinity.
4. To see the effects of different levels of salinity and intensity of defoliation on the chemical composition of grasses.

Significance of the Study

The findings of the above objectives would help in recommending suitable fodder plants for saline rangelands, which may ultimately help in the socio-economic

uplift of the people depending directly upon the produce of saline ranges in Pakistan in particular and other countries, in general.

The study provides empirical evidence to identify suitable plants for saline rangelands, which can increase the palatable vegetative cover and improve range conditions. The overall possible impact based upon the findings of this research would be the socio economic uplift of people depending directly upon the produce of saline ranges in Pakistan. Other benefits that could be accrued from the study include:

1. Improvement of saline rangelands for livestock.
2. Improvement of overall vegetation cover.
3. Improvement of vegetation/ habitats for game bird/ animals and wildlife.
4. Improvement of socio-economic status of the people depending upon saline rangelands.
5. Extension of the knowledge base for further research in the area of salinity, defoliation versus growth of grasses.
6. Findings may also pave way for further research in rangeland ecology.

Limitations of the Study

The study was conducted in laboratory as well as field but with the help of pots. The latter part was according to the temperature and weather conditions of the Peshawar valley. As such the findings may be biased to that extent as per similar works. Results of repetition in field may vary.

REVIEW OF LITERATURE

Much research has been done for evaluating agricultural crop species for their suitability to saline conditions. However, insufficient research has been conducted to evaluate salt tolerant fodder species.

In Pakistan, Pakistan Forest Institute and the National Agricultural Research Council (NARC) have done work mostly on the grasses and fodder crops. Their interest includes chemical composition of grasses (Iqbal *et al.*, 1989), growth performance under non-saline conditions (Noor, 1984; Ashfaq & Amin, 1982), and the effect of salinity on grasses (Tariq & Tayab, 1984; Dagar *et al.*, 1993). Some of the plants tested for their salinity tolerance are *Hordeum jubatum* (Badger & Unger, 1998), *Bouteloua gracilis* (White & Gartner, 1997) and Kentucky blue grass (Horst & Taylor, 1993).

The review of literature indicates that only meagre research has been done in Pakistan on the evaluation of fodder species for their suitability to saline habitats coupled with defoliation (simulated grazing). This challenges us to screen and evaluate fodder species for their suitability to saline conditions. From the practical point of view, the mere cultivation of plants under saline condition would not suffice the purpose. Such plants must be capable of surviving under grazing stress. Grazing affects the growth performance, photosynthetic capability, chemical composition of

fodder species (Benhaja, 1990; Khasanov, 1996; 1991; Pereira, *et al.*, 1995; and Alam, 2002).

REVIEW OF LITERATURE ON GRAZING, AND DEFOLIATION (CLIPPING)

Belton (1990) studied the effect of site and defoliation interval on *Lolium preenne* and *Trifolium repens*. The result showed that differences in production between site and between cuttings intervals was associated with pasture composition.

Cameron *et al.* (1990) studied the effects of defoliation frequency on the performance of *M. sativa* grown alone or in mixtures with *Panicum maximum* or *Cenchrus ciliaris*. Defoliation at 6-12-week intervals had 0 or 100 kg N/ha. In the first 2 years 6-week harvesting increased *M. sativa* yields. During the 1st 2 years *M. sativa* competed strongly against the grasses but in the 3rd and 4th years the grasses gave more yield than *M. sativa*. *M. sativa* increased the N concentration of the grass component of the pastures and increased soil N. Davies & Evans (1990) studied the effects of different spring defoliation treatments and fertilizers nitrogen of white clover in ray grass/clover sward. Results showed that white clover were higher in unfertilised and cut than in fertilized and uncut plants. Hodgson (1990) reported increased tiller density, and decreased growth rate with increasing defoliation in *Lolium perenne*. Oosterheld (1990) stated that in pot-grown grasses, the level and

type of stress under which plants grew affected their response to simulated grazing. Defoliation increased growth rates only if control plants were limited by biomass accumulation. Stressed plants were the most negatively affected by defoliation. Grazing-adapted species grew faster than less adapted species. Ramos & Rodriguez (1990) evaluated the adaptive potential of 20 forage cultivars by cutting at 21- and 28-d intervals during long-day and short-day season, over 1.5 years. The simulated grazing technique in combination with agronomic evaluation was effective for screening many grass accessions within a short time. Cosgrove & White (1990) stated that irrigated *Medicago sativa* was grazed with sheep for 3 or 12-d during summer and autumn. Results showed that for both cycles, regrowth in the early stages was more rapid following a 12-d grazing duration than following a 3-d grazing duration. The faster initial regrowth was a result of a greater number of new shoots ready to begin growth, despite some of the new shoots being damaged by grazing. Miller *et al.*, (1990) found the effect of clipping date and weather on amount of regrowth and total seasonal forage production in *Agropyron desertorum* swards. Phenology and the amount of standing crop were significantly correlated with regrowth. Total seasonal forage production on plots clipped during the boot stage was generally lower than on plots clipped during the vegetative or late-flowering stages of development.

Grant & Borthran (1991) applied different defoliation treatments, i.e. weekly cutting incorporating a period of no cutting and cutting every 3 weeks on mixed sward of *Trifolium repens* and *Lolium perenne*. Results showed that significant treatment effects were obtained after weekly cutting. Grignani (1991) said that in simulated grazing pure swards of *Dactylis glomerata*, *Festuca arundinacea*, *Lolium perenne*, *Phleum pratense* and *Medicago sativa* were grown with or without irrigation. Daily growth rate was lowest in *M. sativa* except in August (hottest month) when it was higher than in all other species. Hill (1991) observed the effect of defoliation every 4 to 8 week on pure stand and binary mixture of *Phalaris aquatica*, *Medicago sativa*, *Trifolium repens* and *T. subterraneum*. Results showed that *Trifolium* species accumulated more herbage from frequent defoliation. In case of other species infrequent defoliation increased herbage accumulation. Mullahey *et al.*, (1991) gave three defoliation treatments to *Andropogon gerardii* and *Calamovilfa longifolia*. Control plots were harvested at the end of growing season. Results showed that multiple defoliation increased yield of both of the grasses while the number of buds and tillers were similar to control at the end of experiment. The number of buds decreased but the DM yield was lower than control for all treatments. Nemoto & Panchaban (1991) observed that electrical conductivity of surface soil under vegetation dominated by *Chloris barbata*, *Ischaenum rugosum* and *Panicum repens* did not increase when protected from cattle grazing. Grazing led to increase of bare

ground, where NaCl accumulated and modified the heterogeneity of vegetation, which was reflected in the degree of salt accumulation.

Rai, (1992) stated seed germination and seedling growth of *Bauhinea purpurea* and *Panicum maximum* when irrigated with saline waters, plant dry weight decreased with increasing salinity.

Saleem & Call (1992) reported that after defoliation the root shoot biomass increased in a 4 weeks interval. *Chrysopogon acheri* produced more root and shoot biomass than *Cymbopogon jawarncusa* and suggested that *Chrysopogon acheri* may not decrease in mixed communities when frequency of defoliation is controlled.

Ahmed *et al.*, (1993) reported that *Brachiaria mutica*, *Pennisetum purpureum* and *Panicum maximum* irrigated with saline water had decreased N, P, Ca and Mg concentrations while Na, K and Zn concentrations increased with increasing salinity. The 3 species gave similar responses to different salinity levels. Han *et al.*, (1993) worked on grasses of Qinghai-Tibetan plateau and reported decreased photosynthetic area LAI and DM in *Cynodon* and *Dichanthium* with increasing grazing intensity. A simulated grazing (clipping) study by Sardar (1993) showed that average forage production was highest in the control indicating that sown *Cenchrus ciliaris* is sensitive to repeated clippings. However, clippings at different intensities and frequencies in different seasons had variable results. Mc Naughton, (1993) reported that grazing can increase net productivity of the grasslands containing species of

Cynodon, *Dichanthium* and *Bothriochloa*. Intrinsic mechanism identified were photosynthetic rate, which contributed to compensatory growth

Kang & Brink (1994) studied the effect of 7, 14 or 28-d cutting intervals on regrowth of *Trifolium repen* cv. Regal, Grassland Huia and *Aberystwyth* S184. Timing of initial defoliation and defoliation frequency in white clover influenced productivity and nodule formation. Khan (1994) applied four defoliation treatments viz: removal of flag leaf and second upper leaf, flag leaf + second upper leaf +, all leaves boot stage to four wheat varieties. Effect of defoliation treatments on 1000-grain weight and grain yield was determined. Defoliation treatments X varieties interactions was significant for both traits. Paez *et al.* (1994) stated that *Panicum maximum* cut at a height of 20 cm increased the rate of photosynthesis and stomatal conductance. Other cutting treatments had no effect on the plants. Rafiq & Sardar (1994) conducted a 5-year study on temperate forest range to investigate the effects of grazing and fertilizer on forage production and cover percent. It was revealed that 2-3 times improvement in forage production through protection (zero grazing) and fertilizer application occurred. Xia *et al.* (1994) showed increasing tiller densities with increasing grazing intensities in *Bromus tectorius*. Zhu *et al.* (1994) reported decreased fresh weight with increasing defoliation rate in grasses of Alpine meadow containing *Cynodon* and *Dichanthium*.

Bardgett & Leemans (1995) found strong correlation between grazing intensity and the growth activity, which he inferred from studies of *Dichanthium* and *Bothriochloa*. Brink (1995) studied the growth and morphology of white clover under different cutting heights and frequency. The effect of cutting height on stolon DM was opposite to its effect on DM yield. It was suggested that close defoliation of white clover (2.5-cm stubble) during the summer and autumn is detrimental to plant survival. Fulkerson (1995) said that leaf number is a criterion for determining defoliation time for *Lolium perenne* and it also depends on the effect of defoliation frequency and height. Hick & Reader (1995) showed that soil nutrients availability affect compensatory growth of defoliated plants. Merchant (1995) examined that defoliation to ground level reduced tussock mass and vigour but a large number of green, living stems remained following all treatments, indicating considerable potential for regeneration once the cutting treatments had ceased. Morrison & Reekle (1995) stated that defoliation of *Oenothera biennis* had dramatic effect on the photosynthetic activity of the remaining tissues. Pasumarty *et al.* (1995) observed that in a sward of *T. repens* seed number per pod was higher in inflorescences obtained from cut plots than from control plots. Rono *et al.* (1995) carried out research work on winter-fat, a range shrub, and observed the increasing number of the shrub in protected rangeland. Density, frequency and canopy cover of winter-fat was significantly higher in protected rangeland than in grazed pasture.

Cosgrove *et al.* (1996) stated that tolerance to grazing and compensatory growth ability of *Dichanthium annulatum* and *Panicum antidotale* have caused survival of plants in the sward. Grant *et al.* (1996) in a controlled grazing studies on *Molinia* grassland found that frequency and severity of defoliation were more important than timings in their effects on *Molinia* grassland and that light and heavy defoliation reduced the number of leaves, tillers and basal cover while those of broad leaved plants increased. Hodgson & Illius (1996) observed the compatibility among *Bromus inermis* and *Agropyron cristatum*, which showed tolerance to the intensity of grazing. Holland *et al.*, (1996) stated that increased exudation in response to defoliation is associated with increased partitioning of carbohydrates to roots, as a means of grazing tolerance. Marriott & Zuazua (1996) in their work on tillering and partitioning of dry matter and nutrients in *Lolium perenne* growing with neighbours of different species found that performance of *Lolium perenne* differed when plants grew with non-specific or heterospecific neighbours and that nutrient supply and severity of defoliation modified the effect. Razmjoo *et al.* (1996) reported that grasses improve in length when mowing height is increased. Thornton & Millard (1996) worked on faster growing species *Lolium perenne* and slower grower *Festuca* species, which differed in relation to the rate of recovery of the lost parts and root functioning.

Donaghy & Fulkerson (1997) studied whole plant response to defoliation and said that flow of organic carbon to the defoliated parts take place and suggested

further research in this context. Donaghy & Fulkerson (1998) said that carbohydrate exudation from the cut tillers is because of high grazing intensity. Keya (1997) conducted study on the effects of defoliation on yield and reproduction of *Indigofera spinosa*. Results showed that *I. spinosa* is highly resilient to browsing. Maximum regrowth compensation was achieved at the moderate clipping. A longer clipping interval enhanced regrowth, especially at the moderate intensity. With heavy clipping reproduction was completely stopped. Ruess *et al.* (1997) in their work on growth responses of *Carex ramenskii* to defoliation, salinity and nitrogen availability concluded that the grazing by geese increased the number of plants in Alaska. It was also concluded that by subjecting *Molinia* to heavy grazing both the quality and quantity of these plants can be improved.

Arredondo & Johnson (1998) conducted a study to evaluate the influence of clipping on root length of 3 range grasses, a cultivar of blue bunch wheatgrass (*Pseudoroegneria spicata*); 'Hycrest', a cultivar of hybrid crested wheatgrass (*Agropyron desertorum* Fisch. ex Link), and cheatgrass (*Bromus tectorum* L.). Greenhouse-grown seedlings were clipped once or twice at 3 intensities of defoliation (0, 50 and 70 %). The total root lengths of the 3 grasses were evaluated at 28, 35 and 42 days after planting. Specific root length in Hycrest and Whitmar decreased through time, cheatgrass did not exhibit changes in specific root length through time. Bhandhari & Mehra *et al.*, (1998) in their study on forage grasses showed that

ungrazed grasses had highest amount of aboveground mass and more flowering culms per clump than the grazed ones.

Baruch & Bilbao (1999) compared the native *Trachypogon pulmosus* with the invader *H. rufa* grasses to study the effect of fire and simulated grazing on net photosynthesis, nutrient content. Results showed that *T. pulmosus* was more affected by defoliation than by burning. Haferkamp & Karl (1999) worked on the effects of defoliation on growth of Japanese brome. Treatments included no clipping or clipping to 75- or 150-mm stubble height biweekly for 65 to 70 days in a greenhouse. Clipping vegetative plants reduced tiller numbers and leaf heights. Reducing stubble height from 150 mm to 75 mm on a biweekly frequency reduced herbage. Increasing frequency of clipping did not generally affect total biomass. Some inflorescences were produced with even the most severe clipping treatment.

Ma *et al.* (1999) and Li & Huang (2001) maintained that a high grazing intensity of above 0.70 of intake of production on natural grass land of *Dichanthium annulatum* and *Cynodon dactylon* resulted in decreased yield and degradation.

Patterson & Sim (1999) demonstrated increased release of organic compounds from roots of *Lolium perenne* in response of defoliation. Reuter *et al.* (1999) claimed that production of forage of three cool season grasses was greatly reduced as a result of grazing. These forage grasses were grown during spring as complementary forage

for wheat pasture. Patterson and Sim (2000) showed the effect of defoliation on loss of organic compounds from roots of *Festuca rubra* resulting in decreased root weight.

Alshamarri *et al.* (2000) observed that salinity levels of 9.0, 10.4, 20.0 and 28.5 dsm-1 in Kentucky blue grass, tall fescue, salt grass and alkali grass caused 50% shoot growth reduction respectively. Fainestock & Detling (2000) studied the effects of long term grazing on the morphology of two perennial grasses *Elymus spicatus* and *Pseudoroegneria spicata* and reported morphological modifications like reduction in shoot and leaf length. Jan *et al.* (2000) worked on salinity tolerance of some turf grasses reported that alkali grass is highly tolerant to ECe of 9-12 while tall fescue was moderate to highly tolerant from ECe 6-9. Perennial Rye grass had moderate tolerance from ECe 3-6. Schäufele & Schnyder (2000) in a study on perennial ryegrass (*Lolium perenne* L.), said that decreased cell production and expansion may be related to limited C and N assimilate supply to the leaf growth zone due to low residual photosynthetic activity, Defoliation related reduction of cell expansion was in the distal part of the leaf growth zone, whereas defoliation had no effect on cell expansion in the basal part of the leaf growth zone. Virgona & Bowcher (2000) worked on the impacts of variations in grazing intervals under irrigated condition on basal cover. *Phalaris aquatica*, *Dactylus glumerata*, *Festuca arundinacea* and *Danthonia richardsonii* for 2 years. Basal cover of grasses increased with increase in grazing interval of 5 weeks and this was also related to water supply except *Phalaris*

which was active both in rain fed and irrigated condition. Dong (2001) stated that persistence of *Bromus* sward is because of low grazing intensities.

Oba *et al.* (2001) stated that response of a plant to grazing depends on the intensity of the grazing gradient in perennial grasses, *Bromus inermis* and *Elymus nuatans*. Ockerby *et al.* (2001) said that vegetative growth of plants depends on the level and interval of defoliation. Grain *Sorghum* plants defoliated above the first ligule grew vegetatively producing more biomass than those defoliated above the second ligule. Defoliation adjusted the biomass and yield potential of the crops

Bennet & Richard (2002) reported salt tolerance limits for some plants including Pasture species. They termed *Chloris gayana*, *Trifolium repens* and *Triticum aestivum* slightly saline. Jones (2002) stated that the most important variable in grazing is the time during which grasses are under pressure. When grazers are kept in a sward continuously, they "high-grade" the select bits, often regrowing tender young growth before enough foliage regrows to replenish root reserves. This greatly affects the vigour of the plants and biomass partitioning. Marcar *et al.*, (2002) suggested low to moderate salinity tolerance in *Melaleuca lanceolata* and *Melaleuca decussata*. Shin & Naoki (2002) reported that NaCl reduced the relative growth in *A. stelliriana* significantly. Dong *et al.* (2003) stated that *Agropyron cristatum* was less tolerant to grazing and disappeared after grazing while *P. crymophila* was the most tolerant grass species and could be introduced to replace *Agropyron cristatum*.

Newberry (2003) identified cultivars of *Poa pretensis* that maintained vigorous shoot and root growth at salinity greater than 3-6dSm/l.

Dong *et al.* (2004 a, b) observed increasing tiller densities and decreased photosynthetic rate, leaf area index and herbage mass in *Bromus inermis*, *Cynlymus nutans*, *Elymus nutans* and *Agropyron cristatum* with increasing grazing intensities. Marcar *et al.* (2004) reported lowest survival rate and low annual growth rate at 7.5cm level of cutting in *Quercus macrocarpa* seedlings at low salinity. Mansk (2005) stated that after defoliation carboxylase activity increases in grasses that include increased rate of CO₂ conductance and carbohydrate storage.

REVIEW OF LITERATURE ON SALINITY

Amzallage *et al.* (1990) observed that the treatment of *Sorghum bicolor* with abscisic acid (ABA) during the first week of salinization with 150-mol m³ NaCl induced enhancement of high salinity (300 mol M³ NaCl). Results indicated that low ABA concentration is not sufficient to induce survival of plants in high salinity (300 mol m³ NaCl). Ansari *et al.*, (1990) reported that all levels of salinity adversely affected various growth parameters Thatta, H-O-I and Mayak cultivars of sunflower. The dried matter production of Mayak was more than Thatta and H-O-I. Datta *et al.* (1990) studied germination and growth properties of 16 Khareef crops including some oil yielding crops at 4,8,12 and 16dSm⁻¹ level of NaCl. Reduced germination,

growth and yield were noted. Drew *et al.* (1990) reported reduced transpiration and stomatal conductors in cucumber with increasing NaCl salinity. Alonso, *et al.* (1990) reported reduced forage production in Italian rye grass due to salinity. Baye (1990) worked on the comparative growth response and population ecology of European and American beach grasses (*Ammophila* spp) in relation to salinity. Reduced germination, growth and yield were noted.

Keng (1990) studied phenotypic responses of *Agropyron smithii* Ryd 6 (Western wheat grass) in saline environments. The results indicated that there was a difference in the values of foliage coverage and biomass of *A. smithi* growing in soils with effect of different NaCl concentration added to culture media. Seeds were germinated, transplanted into nutrient solution with NaCl salinities. NaCl reduced plant height, length of culms and number of culms per plant. Kim (1990) worked on photosynthesis and respiration of forage plants orchard grass (*Dactylis glomerata*), *Medicago sativa* and white clover under saline stress. Root damage due to seawater was characterized by brown coloured root cortex in *D. glomerata* and *E. arundinacea* and water penetrations of root cortex in *M. sativa* and *T. repens*. Kumar & Sharma (1990) observed the germination of *P. minor* seeds and claimed that the process of germination progressively decreased by increasing concentration of saline solution containing sodium, calcium, potassium and chloride. Oymada (1990) stated variation and characteristic of sodium accumulation in grasses. He

observed the effects of 0, 100 and 1000 ppm NaCl on growth, Na and K contents of 15 grass species including oats, maize and eleusine coracene in a pot experiment for classifying them in relation to specific sodium accumulation. Slow growth rate was observed in them. Petro & Rybkina (1990) experimented with the reaction of wheat millet and sorghum plants to NaCl salinization. They observed that relation of Na^+ flow in to above ground and Na^+ flow in roots was the most sensitive indicator of salt resistance of wheat than sorghum. It was shown that species and varieties of plants with higher relative growth rate were less resistant to salinization. Marcum & Murdoch (1990) conducted a study to compare growth and physiological responses of eleven C_4 turf grasses to salinity. Grasses were grown in solution culture in glasshouse with NaCl salinities of different levels. Tolerant grasses included *P. vaginatum*, Augustine grasses, manila grass; Bermuda grasses were less tolerant to salinity. Mariam (1990) observed the growth and physiological responses of coastal salt marsh grass salinity she compared relative shoot growth reduction with increasing salinity. C_2 Coastal salt marsh grass), seashore Paspalum (*Stenotaphrum secundatum*) and Molina grass (*Zoysia matrella*) and Manila grass (*Zoysia matrella*) were consistently ranked as the most salt tolerant species. The Bermuda grasses (*Cynodon* spp.) was intermediate in salt tolerance, the common Bermuda grass (*Zoysia japonica*) was salt sensitive and caused shoot death at relative low salinities. Noble *et al.*, (1990) irrigated *Trifolium repens*, *Lolium perenne* and

Paspalum dilatatum with saline ground water at different salinities levels. The result showed that *T. repens* was similar in all treatment at the beginning of the growing season. But both season high stress of 4 and 5 showed reduced *T. repens* in half of the season. Kumar & Kumar (1990) reported decreased seed yield of *Brassica Juncea* with increasing salinity level.

Nanaiah & Krishnan (1990) reported higher survival rate of the diploid *Solanum viarum* plants at the lowest salinity levels. The plants proved susceptible to high salinity level. Onkware (1990) found the effect of salt stress on water relation and photosynthesis in finger millet and recorded decreased leaf water potential and transpiration under increasing levels. Singh *et al.*, (1990) recorded decreased transpiration rate and stomatal conductance in eight *Brassica nigra* genotypes grown in pot culture under different soil sodicity. Warne *et al.* (1990) observed the effect of NaCl on growth, morphology, photosynthesis and water use efficiency of *Chenopodium rubrum* and reported decreased stomatal conductance with increasing salinity

Clipson *et al.* (1991) reported reduced fresh weight of shoot of *Linum usitatissimum* at 50 and 150 mM NaCl concentration. They concluded that *L. usitatissimum* was more salt tolerant than many glycophytes. Devitt *et al.* (1991) observed 2-year-old *Cynodon dactylon* stands grown in large columns containing sandy loam silt loam or clay soils and grown with saline water, Dry matter decreased

with increasing irrigation water salinity at each irrigation frequency in sandy loam and silt loam soils. DM increased in the clay soil. Yield decreased as irrigation frequency increased at all irrigation salinity levels. Kalaji & Nalborczyk (1991) observed that increasing NaCl concentration (30-170mol/m³), decreased the growth rate leaf area total DM, photosynthesis and transpiration in 8 barley cultivars. Jain *et al.* (1991) reported decreased germination percentage and declined radical, hypocotyle and total seedling length of *Trigonella foenumgraecum* at increased salt concentrations. Khader (1991) worked on the effects of different salts on the germination and radical growth of *Datura fastusa* and *D. stramonium* seeds and reported decreased germination percentage and reduced radical growth. Khier *et al.* (1991a,b) reported increased plant growth in up to 3000 ppm of NaCl which decreased by 4500 ppm NaCl in *Linum usitatissimum* grown in pots and irrigated with water containing 0, 1500, 3000, or 4500 ppm NaCl. Seed yield and its oil concentration increased upto 3000ppm NaCl treatment. Kumawaat *et al.* (1991) recorded declining values of transpiration rate in pearl millet under increasing levels of EC in irrigation water. Leidi *et al.* (1991) observed no effect on the photosynthetic or transpiration rates in wheat. However, stomatal conductance decreased with increasing NaCl salinity. Mohammed & Burrage (1991) recorded reduced stomatal conductance in tomatoe (*Lycopersicum esculentum*) grown in highly saline environment. Singh & Singh (1991) reported *Linum usitatissimum* Var. Neelam as

the most tolerant one to high salinity and observed that reduction in growth, total nitrogen, protein, RNA, DNA, chlorophyll and accumulation of proline occurred with increased sodicity stress.

Ali *et al.* (1992) reported decreased germination percentage, length and fresh weight of radicals of *Trigonella foenum-graecum* while rate of respiration increased sharply with increasing NaCl level from 0 to 160mM. Hussain & Ilahi (1992) reported that germination of *Brassica campestris* L. Cv. *Torch* and *Altex* was unaffected upto 7.5dSm^{-1} of MgSO_4 and Na_2SO_4 or its mixture. At 15.0 dSm^{-1} levels of MgSO_4 completely inhibited germination while similar concentration of Na_2SO_4 gave high germination percentage for Cv. *Torch* and *Altex*. Seedling growth decreased at salt concentration greater than 2.5dSm^{-1} . Liedi *et al.* (1992) determined decreased transpiration rates and stomatal conductance in peanut and cotton plants when subjected to the highest NaCl salinity levels. Lyra *et al.* (1992) observed significant differences among cultivars of *Sesamum* at different salinity levels with regard to germination, percentage and rate of germination, vigour, fresh weight and dry mass. Weight of 1000 seeds decreased with increasing salinity. Tanczos *et al.* (1992) investigated low temperature tolerance of *Plantago coronopus* and *P. maritima* as affected by various concentrations of NaCl salt and concluded that roots of these plants were more frost sensitive than shoot.

Al-Harbi *et al.* (1993) while testing the effect of NaCl salinity on growth of cucumber (*Cucumis sativus L.*) recorded reduced transpiration rate and stomatal conductance by increasing salinity. Grieve *et al.* (1993) studied the effect of induced NaCl salinity on grasses and reported a progressive decrease in tillering capacity, lesser number of spikes/ plant and reduced seed yield. Geogrieve & Atkins (1993) reported decreased stomatal conductance and leaf water potential in cowpeas due to NaCl salinity. Hussain *et al.* (1993) found reduced germination and seedling growth of two cultivars of *Cicer arietinum* tested under induced salinity levels of 2.5, 5.0, 7.5, 10.0 12.5 and 15dSm⁻¹ of NaCl and Na₂SO₄. Letchamo *et al.* (1993) observed significant differences and linear relationship against traits like plant height, number of internodes and number of leaves per plant in *Passiflora edulis* with increasing EC levels. Leaf water potential sharply declined as EC increased. Morales *et al.* (1993) reported decreased yield, branching and siliqua/plant in *Brassica juncea* and insignificant effects on 1000 seed weight and seed/siliqua under irrigated saline water. Valia *et al.* (1993) while testing the effects of various levels of ESP (exchangeable sodium percentage) on growth and physiological parameters reported decreased transpiration rate in passionflower (*Passiflora edulis Sims*). Wright *et al.* (1993) found that stomatal conductance were greatest in the unsalinized *Vaccinium asheir*. Ayoub (1994) reported that seed of *Cassia acutifolia* were highly tolerant to 16.0 mhos/cm salinity and germinated well. The survival of young plant and total pod

yield was significantly reduced in soil salinity higher than 11.0 m mhos/cm. Bharti & Singh (1994) claimed that the addition of 2 and 10 EC NaCl to the nutrient media slightly decreased the fresh weight of the roots of *Sesamum indicum*, whereas it increased the leaf fresh weight and also dry weight of different plant parts. Boem *et al.* (1994) stated that in *Brassica napus* the plant height, number of seed and pod per plant decreased while, formation of siliqua and seed filling was delayed with salinity above 6.0 dSm^{-1} . Choukrullah *et al.* (1994) studied the effect of salt stress on ion uptake, osmoregulation and plant water relations in *Vicia faba* and reported decreased leaf water potential and transpiration rate. Hamada & ElEnany (1994) reported reduced growth rate in pot grown *Vicia faba* under increasing soil salinity up to 160 mM NaCl. Katerji *et al.* (1994) worked on sunflower and maize and reported that increasing salt concentration decreased leaf water potential and stomatal conductance during early growth of seedling of sunflower and maize. Mahmood *et al.* (1994) studied an alluvial saline site in Pakistan with severely restricted water penetration and with patchy cover of grasses, i.e., *Cynodon dactylon*, *Desmostachya bipinnata*, *Atriplex crassifolia*, *Eleusine flagellifera* and *Suaeda fruticosa* are described. *Suaeda fruticosa* was the best indicator of salinity; *L. fusca* achieved luxuriant growth on saline soil. Renovated areas showed an increase in plant colonization over a 5-year period as soil conditions improved. Khanzada & Ansari (1994) reported reduced biomass yield, nitrogen contents in foliage and quantity of nitrogen fixed by lucerne,

berseem and sesbania as affected by salinity. Nitrogen fixation was adversely affected than the vegetative growth. Naqvi & Mahmood (1994) reported that fresh and dry weight of shoot and roots of *Sesbania sesban* decreased with increasing levels of sodium chloride. Ilahi *et al.* (1994) reported that increasing salinity levels affected the uptake and accumulation of various elements in the aerial portions of three cultivars of sunflower subjected to various levels of different salts including NaCl. Khan *et al.* (1994) observed decreased germination, radical and plumule growth in *Helianthus annuus* with an increase in the salinity levels created by different salts. Zaheer *et al.* (1994) worked on some forage legumes and reported that salinity had retarding effect on shoot and root length, fresh and dry weight and on root volume. Development of pods/plant decreased while the number of seed/pot remained unaffected. The number, size, shape and colour of root nodules were negatively affected with increasing salinity. Shen *et al.* (1994) reported that the rate of photosynthesis and stomatal conductance decreased in barley with increasing salinity. However, leaf water potential increased when salinity level increased. Siddiqui (1994) worked on tree plantation for sustainable use of soil and water with special reference to the problem of salinity. Besides other things, he provided the current status of research and development need for further research for reclamation of saline and waterlogged soil with biological methods. Ahmad & Zaheer (1994) grew *Sporobolus arabicus* and *Sesbania aegyptiaca* alone or in a mixture at 2 densities and irrigated

with fresh or saline waters. The lower salinity level increased growth of *Sporobolus* but did not affect *Sesbania*, while at the higher salinity level growth of *Sesbania* was decreased but that of *Sporobolus* was not affected. High salinity increased proline contents in *Sesbania* at low plant density. *Sesbania* did not affect productivity of *Sporobolus*.

Ashraf & Ahmad (1995) exposed 8-week-old plants of *Leptochloa fusca*, *Cynodon dactylon* and *Panicum turgidum* to NaCl or water logging, or NaCl + waterlogging for 5 weeks in greenhouse conditions. There were no significant effects on the biomass production of *L. fusca*, whereas an inhibitory effect of salt and water logging was observed on *C. dactylon*. All the stresses severely inhibited the growth of *P. turgidum*. Ashraf *et al.* (1995a) analysed the effect of salinity (NaCl) and polyethylene glycol (PEG) at 150 osmotic concentrations, on germination seedling growth and water uptake of two *sorghum* varieties. They reported that ISS-1347 was a tolerant and IS-18348 was sensitive variety. Ashraf *et al.* (1995b) worked on the two *L. prene* cultivars selected for longest roots and no roots respectively. After 3-week growth in NaCl solution with different levels the high selection line had significantly higher root growth compared with low selection and unselected lines at all salt concentration pair grasses made between the high selection and the low selection lines with NaCl indicated that the additive genetic component was quite high for both the salt treatments. Ayala & Leary (1995) reported that at the lowest

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salinity levels in *Salicornia bigelovii*, transpiration rate was significantly higher. Increase in salinity resulted in decreased stomatal conductance. Beke & Graham (1995) recorded greater dry weight of *Linum usitatissimum* on moderately saline soil. In saline treatment potassium and sodium ions concentrations was also higher. Jafari (1995) studied the salinity tolerance of seven *Agropyron elongatum* accessions and indicated considerable difference between the accessions in salinity tolerance. Xu *et al.* (1995) reported decreased stomatal and cuticular transpiration of greenhouse tomato plants in response to high solution electrical conductivity.

According to Singh (1995) growth and biomass production of *Prosopis juliflora* was greater in a sole stand than when interplanted with the grass *Leptochloa fusca* but soil improvement was greater for the mixed tree/grass treatment.

Rasul *et al.* (1996) concluded that salt tolerance culture with a root medium electrical conductivity (EC) decreased seed germination and growth in guar ecotype. It was calculated that EC of 1.9 dSm^{-1} imposed after 2 weeks of growth decreased DM yield of 8-week old plants by 50% compared with the control shoot. Ca content was not affected by salinity. Ashraf (1997) salinized *Cenchrus pennisetiformis*, *Leptochloa fusca*, *Diplachna fusca* and *Panicum turigdum* with 0 (control) or 150 mol m^{-3} NaCl. Shoot fresh and dry biomass of *C. pennisetiformis* and *P. turigdum* decreased significantly with salt treatment. Whereas those of *L. fusca* remained almost unaffected. Total soluble leaf proteins in both *C. pennisetiformis* and *L. fusca*

decreased with the salt treatment compared to those in the control and was marked in *C. pennisetiformis*. In contrast, soluble leaf proteins of *P. turgidum* increased considerably by salt treatment. Singhania *et al.* (1997) grew para grass (*Brachiaria mutica*), guttan panic *Panicum maximum*, blue panic (*P. antidotale*), Rhode grass (*Chloris gayana*) and swan grass (*Lasiurus indicus*) under saline water. Rhode grass gave the higher green forage yield (41 t/h) followed by the blue panic (33.1 t/h). The guttan panic was the lowest green forage yielding plant. Pedrol *et al.* (1998) grew pure and mixed stands of *Holcus lanatus*, *Koeleria glauca*, *Lolium perenne* and *Dactylis glomerata* showed that germination percentage was greatest at 75% at 2 different salinity levels. *Holcus lanatus* had the least reduction of leaf size due to stress and had the highest water use efficiency and accumulation of free proline. Wild genotypes of *Holcus lanatus* and *Dactylis glomerata* had high competitive ability. While *Koeleria glauca* suffered more under competition from either grass. Worku & Champan (1998) exposed the leaves and branches of *Cynodon dactylon* to various concentrations of NaCl and KCl salt solution. Salt secretion was observed first as droplets and later on as salt crystals. The salt was secreted by salt glands. Salt secretion of *C. dactylon* had an ecological significance in maintaining low salt levels in the shoots.

Alonso *et al.* (1999) observed that the forage production was reduced in saline environments. Viability of 56 seeds of Italian rye grass (*Lolium multiflorum*) was

found out for germination under saline conditions utilizing NaCl levels. Cluster analysis when performed showed four groups according to their germination behaviour. Marcum (1999) evaluated the responses of a number of important forage and turf grass genera towards salinity tolerance mechanism. Grasses were exposed to salinities up to 600 mM NaCl in solution culture. Salinity tolerance decreased in the following order. *Distichias spicata*, *Sporobolus airoides*, *Cynodon dactylon*, *Zoysia japonica* and *Buchloe dactylodies*. Relative root length (RL) and (RW) root growth increased under saline conditions relative to control. Salinity tolerance was positively correlated with Na and Cl ions gland secretion rates.

Abdi (2000) studied the salinity tolerance of three species of clover (*Trifolium pretense*, *Trifolium repens* and *Trifolium respinatum*) and reported significant reduction in germination of the individual species and concentration level effect on the three experimental species. Jan *et al.* (2000). reported salinity tolerance of some turf grasses and said that alkali grass is highly tolerant to ECe of 9- 12, while tall Fescue is moderate to highly tolerant from ECe 6- 9, Perennial Ryegrass has moderate tolerance from ECe 3- 6 while Kentucky bluegrass is the least tolerant from ECe 3- 6. Marcar *et al.* (2002) suggested low to moderate salinity tolerance in *Melaleuca lanceolata* and *Melaleuca decussata*. Marcar *et al.* (2004) reported lowest survival rate and low annual growth rate at 7.5 cm level of cutting in *Quercus macrocarpa* seedling at low salinity. Plaut *et al.* (2000).found greater reduction in dry weight

together with increased signs of salt damage and related them to salt sensitivity criteria for *Oryza sativa*, *Sorghum vulgare* and *Hordeum vulgare*. Qian *et al.* (2000) conducted two greenhouse studies to determine the salt tolerance of 29-Zoysa grass (*Zoysia* spp.). Sodium chloride was gradually added to nutrient solution to obtain a final salinity level of 42.5 dSm^{-1} . Relative salt injury was associated with zoysa grass leaf length and texture. Short, fine leaf-textured zoysiagrass and their hybrids) were most salt tolerant, coarse leaf-textured entries (*Z. japonica* Steud. and their hybrids) intermediate, whereas long, fine leaf-textured entries ('Cavalier, Emerald and Zeon) exhibited the least salt tolerance. Suplick *et al.* (2000) concluded that salinity decreased shoot and root biomass in Kentucky blue grass and Fylking cultivar of Kentucky blue grass performed better than Merion Kentucky blue grass under similar salt stress. Wilson *et al.* (2000) stated that different plant species of rice tested under saline condition might show a different behaviour at different growth stages. Plaut *et al.* (2000).found greater reduction in dry weight together with increased signs of salt damage and related them to salt sensitivity criteria for *Oryza sativa*, *Sorghum vulgare* and *Hordeum vulgare*. Akhtar *et al.* (2001) reported that salt sensitivity changes considerably during the developmental stages of plant growth and seed yield in grasses. Javed *et al.*, (2001) concluded that at different growth stages tolerance towards salinity in different crops is quite variable. Qian *et al.* (2001) investigated growth and physiological responses of two Kentucky bluegrass cultivars: Limousine

and Kenblue to a range of salinity levels. Grasses were grown in solution culture and exposed to salinity levels of 2.2, 5.2, 8.2, 11.2 and 14.2 dSm⁻¹ for 10 weeks.

Limousine maintained 52% lower shoot Na⁺, 30.4% lower Cl⁻ and 52% higher shoot K⁺/Na⁺ ratio than Kenblue at the highest salinity level. These results suggest that salinity tolerance in KBG is largely attributable to maintenance of higher root growth and higher K⁺/Na⁺ ratio and less Cl⁻ accumulation in shoots. Qian *et al.* (2001) reported tolerance to salinity in sugarcane may be more related to the Na⁺:K⁺ ratio in the cell than the absolute Na⁺ concentration. Shani & Dudley (2001) observed self-regulatory process for salt tolerance in *Avena sativa*.

Akram *et al.* (2002) reported that the four developmental stages of plant growth including germination, reproductive and seed yielding stages can be distinguished with respect to salt tolerance that varies with genotype in grasses

Kamal *et al.* (2003) also investigated effect of salt stress on plant biomass and some biochemical parameters of soybean (*Glycin max (L)* Merr.) under three NaCl levels, control 3.0, 4.5 and 6.5 dSm⁻¹. A marked increase in Na⁺ and Cl⁻ contents were observed whereas K⁺ and N contents were lower than that of the control

Wahid, (2004) determined the comparative response of a salt-tolerant and salt-sensitive canarygrass to toxic effects of sodium chloride. The tolerant canarygrass seedling produced supplementary tillers in greater number. All the parameters of salt-sensitive plant were negatively correlated with EC, Na⁺, and Cl⁻. Salinity reduced the yield,

REVIEW OF LITERATURE ON *BOTHRIOCHLOA PERTUSA*

Bisht and Gupta (1985) made assessment of the net primary production; its annual transfer dynamics and the system transfer functions of the inter-compartmental changes in sub-tropical grassland dominated by *Bothriochloa pertusa*. Transfers function of total net production to aboveground net production was higher than the transfer to underground net production. As much as 58% of the green aboveground net production moved into standing dead but faster rate of litter conversion from standing dead was observed.

Farooq *et al.*, (1989) reported that *Bothriochloa pertusa*, *Dichanthium annulatum*, *Panicum antidotale*, *P. coloratum*, *P. turgidum*, *Pennisetum orientale* and *Themeda anathera*, grown experimentally at Jamrud, Pakistan, were collected and analysed. The results obtained compared favourably with those of common grasses of Cholistan, Kalachitta area and Thal and their propagation as a cattle feed on a pilot scale is recommended.

Rizwan *et al.*, (1994) worked on comparative salt tolerance and composition of cell sap for Na, K, Ca and Cl. of *Sesbania aegyptica*, *S. aculeata*, *Elucine corasana* and *Sorghum bicolor*. Results indicated that fresh and dry weight of shoots decreased with increasing salinity. A 50% reduction in the whole plant biomass was

observed at a much higher salinity level. With increase in salinity K and Ca decreased significantly.

Kaul & Vats (1998) stated that the chemical composition of the essential oil of *Bothriochloa pertusa* (L) revealed the major categories of terpenoids as monoterpene hydrocarbons (26.45%), oxygenated monoterpenes (7.29%), sesquiterpene hydrocarbons (4.73%) and oxygenated sesquiterpenes (37.05%), in 82.31% of the total value constituents identified.

Qureshi *et al.*, (2000) conducted study on chemical analysis of *Euclyptus* and reported that salinity reduces nitrogen contents in plant parts of *Euclyptus*.

Akhtar *et al.*, (2002) stated that salinity decreases nitrogen contents in leguminous plants, decreases nitrogen fixation and inhibited nodulation in leguminous plants.

REVIEW OF LITERATUR ON DICHANTHIUM ANNULATUM

Misra & Singh (1982) stated that total non-structural carbohydrates of grasses under varying clipping regimes in *Polypogon monspeliensis*, *Echinochloa colonum* and *Dichanthium annulatum* were determined. It was greater in *Dichanthium annulatum* as compared to other species. Prasad (1993) carried out a study on *Dichanthium annulatum* to assess the effect of grazing on chemical composition of *D. annulatum* in rainy, winter and summer seasons. The nutritive value of *D. annulatum*, that is, crude protein, ether extract, nitrogen free extract, phosphorus, calcium and

potassium were found higher on grazed grassland compared to protected grassland except crude fibre and ash. Ashraf & McNeilly (1994) studied the responses of three arid zone grass species *Cenchrus pennisetiformis*, *Dichanthium annulatum* and *Panicum turgidum* to five N levels. Biomass production and growth rate of *D. annulatum* were not as affected under N-deficient regimes as the other two species. *D. annulatum* maintained almost uniform shoot N concentration and chlorophyll contents at all assessed N levels. Leaf soluble proteins decreased in *D. annulatum* (19.58-36.98% compared to control), *D. annulatum* was found to be highly efficient in N utilization under N-deficient regimes compared with *C. pennisetiformis* and *P. turgidum*. Prasad (1995) studied protected and grazed grasslands. The total number of grassland species were recorded 11, 9 and 7 protected, 30, 21 and 16 on grazed grasslands in rainy, winter and summer seasons, respectively. The percentage of therophyte was higher on grazed grasslands than protected one. *Dichanthium annulatum* had maximum IVI in each season on protected and grazed grasslands.

REVIEW OF LITERATURE ON PANICUM ANTIDOTALE

Jung *et al.*, (1990) conducted a study on one cultivar each of *Panicum antidotale*, *Bothriochloa caucasica*, 4 of *Andropogon gerardii*, 6 of *Panicum virgatum* and 5 of *Sorghastrum nutans* were grown in field trials near Milesberg, Pennsylvania in 1978-86. Mean yield response to N varied greatly among cultivars.

Forage N concentration varied with cultivars. Stem density and height response to N varied with species and cultivar. Shahi & Sen (1990) reviewed the classification of world and Indian grasslands, especially those of the deserts, on the basis of edapho-climatic factors. Desert grasses such as *Cenchrus ciliaris*; *C. setigerus*, *Lasiurus scindicus* and *Panicum antidotale* are recommended for cultivation to obtain better quality fodder for livestock. Rabotnikof *et al.* (1995) stated that samples of standing DM of *Bothriochloa bladii*, *Digitaria eriantha subsp. eriantha*, *Eragrostis curvula* cv. *Don Eduardo*, *Tanganika* and *Panicum antidotale* cut on 5 dates each between 17 March and 15 September 1985 were subjected to NIRS analysis and the results compared with those of conventional chemical analysis. Prediction of in vitro digestibility and CP contents were very accurate and estimation of lignin content was adequate but prediction of NDF was poor. Belyuchenko & Shatalova (1994) claimed that in *Panicum antidotale* and *Phleum pratense* when treated with distilled water or with 50-200 mg Cu, Zn or Mo/litre altered nutrient accumulation in the seedlings, P accumulation was unaffected by treatments whereas K decreased with 200 mg Mo or 50 mg Zn but increased with 50 mg Cu or 200 mg Zn. Trace element treatment generally increased starch accumulation in seedlings, while 200 mg Zn and 100 and 200 mg Mo in *Panicum antidotale* and increased accumulation by 100 mg Mo in *P. pratense*. Sultani (1999) stated that forage grasses growing at NARC nursery were clipped during spring and monsoon seasons and data on fresh and dry weights were

recorded. *Panicum antidotale* ecotype RMF 254 was the highest yielding with 8.66 t/ha dry matter followed by ecotype RMF 247 with 7.13 t/ha while the ecotype RMF 251 was the lowest yielding (less than 5 t/ha dry matter). Different ecotypes of *Panicum antidotale* were relatively low yielding with less than 5 t/ha dry matter. Mot grass during monsoon season produced almost 100 t/ha fresh and 30-t/ha dry matter. Zeng & Michael (2000) said that plants of rice cultivar M-202 was grown in a greenhouse in sand and irrigated with nutrient solutions of control and nutrient solution was amended with NaCl and CaCl₂ (2:1 molar concentration) at 1.9, 3.4, 4.5, 6.1, 7.9, and 11.5 dS m⁻¹ electrical conductivity for test species. Seedling growth was significantly reduced by salinity at the lowest salinity treatment, 1.9 dS m⁻¹. At 1.9 and 3.4 dS m⁻¹, Seedling survival was significantly reduced when salinity was 3.40 dS m⁻¹ and higher. Reductions in seedling survival, tiller number per plant, and spikelet number per panicle were the major causes of yield loss in M-202 under salinity.

REVIEW OF LITERATURE ON NUTRITIONAL STATUS AND CHEMICAL EVALUATION OF SOME FORAGE PLANTS

Vallentine (1990) reported that *Artemisia* had 9.4% crude protein, 0.67% phosphorus, 51% total digestible nutrients and 0.58 (Mcal/Kg) metabolised energy. Rana *et al.*, (1990) reported 64 - 75% moisture in leaves, 29.6 to 83% in stems while 1.6 - 4.5% ash in stems and 2 to 4.6% in leaves. They determined proximate composition and mineral constituents of seeds and recommended as food supplement

with tropical legumes to improve the animal production by increasing their protein availability. Pierro & Bryant (1990) reported that forbs consisted of 10% of the diet of grazing livestock. The level of crude protein decreased from 13.6 to 5.6% with maturity of vegetation. Feed intake was 82.8 g/Kg in dry season compared with 99.7 g/Kg body weight in other season. Wahid (1990) reported that crude protein contents of some grasses were 18.06% in May and reduced up to 3.95% in September. Phosphorus was 0.13 to 0.05%. While neutral detergent fibre increased 22.39 to 57.93% with the advancing seasons. Kurganova & Oloyannikova (1993) estimated productivity in unimproved rangelands in semi-desert. They considered *Tanacetum achilleifolium* and *Kochia prostrata* highest quality native forage as they had 12% and 10.6% crude protein respectively. While *Medicago romanica* and *Artemisia pauciflora* respectively had 13.3% and 13.1% crude protein. The productivity of re-sown rangelands was 2 to 3 fold than that of natural rangeland. Liu (1993) chemically compared forage samples of rangelands. He reported that crude protein was 9.22% and crude fibre was 30.01% in arid rangeland, (CP 8.55%, CF 30.71%), typical rangeland, (CP 8.06%, CF 30.71%) in desert and (CP 7.32%, CF 32.12%) in pasture. Nitrogen Free Extract (NFE) content was highest in pasture (44.41%) and in arid rangeland 38.1%, while it was 35.36% in desert. Ash contents were higher, 24.41% in May, 8.88% in April, 11.69% in October and 11.26% in December. While neutral detergent fibre increased 22.39 to 57.93% with the advancing seasons. Robles

& Boza (1993) investigated nutritional value of vegetation and reported that crude protein contents of shrub species were higher (11.1%) than that of perennial herbaceous species (9.8%) and annual grassland (9.4%). Although lignin contents were also higher (13.6%) in shrubs compared with 6.3% and 6.5% in perennial and annual herbaceous species, respectively. Saleem (1993) reported that the essential oil contents of *Cymbopogon jawarancusa* are regarded as an avoidance mechanism. However, biomass and crude protein was greater in *Chrysopogon aucheri* than *Cymbopogon jawarancusa*. Ashraf *et al.* (1995a) studied proximate composition of different indigenous Rabi and Kharif fodder. They reported that dry matter and crude fibres (CF) were invariably higher in Berseem at final cuttings. It contained from 19.4 to 20.11%. Crude protein, ether extract and ash contents were higher at primary cutting and lower at later cuttings. Crude fibre was more at final cuttings.

Ashraf *et al.*, (1995b) analysed different varieties of Rabbi and Kharif fodder at different growth stages for cell wall constituents. They reported that Agati variety of *Berseem* showed higher neutral detergent fibre (NDF), hemicellulose and lignin. Cellulose and acid divergent fibre (ADF) were higher in Composition, while silica was higher in Khdravi variety of Berseem. In Lucerne hemicellulose was 8 to 9 time higher than others. Nyamangara & Ndlovu (1995) reported that crude protein level of animal diet ranged from 128-to 157-g/Kg body weights over the season. Neutral detergent fibre contents ranged from 590 to 790 g/Kg. It was highest in wet months

and lowest in dry months. Feed intake ranged from 33-to 60-g/Kg body weights. Feeding duration of 5 hours/day was adequate for maintenance but insufficient for optimum production. Peres *et al.* (1995) studied above ground biomass, protein, fibre contents and nutritional quality in semi arid grassland. The crude protein, neutral detergent fibre and hemicellulose contents were higher on the low altitude area than upper slopes, while lignin content was lower. Theunissen (1995) reported that highly palatable grass *Themeda triandra*, *Eragrostis racemosa* and *Digitaria eriantha* had higher level of total phenolics compared with less palatable ecotype with low level of phenolics. Dutoit & Alard (1996) reported that there were no significant differences between chemical composition of grazed and ungrazed plots. Grazed leaves and barks were rich in calcium and chlorine. However, there is a risk of mineral deficiency for those animals, which stay for a long time in unimproved grassland and eat species poor in minerals. Rahman & Mackintosh (1996) reported that concentration of potassium was high in samples preferred by sheep than in less preferred samples. Sheep preferred optimum potassium level of 1.16% in *Atriplex cineraria*. While very high (3.64% or very low 0.2%) potassium concentration adversely affected preferences of sheep for plants. Holecheck *et al.* (1998) reported that crude protein was 10 to 16% in actively growing forage after defoliation, while it dropped to 6% during dormant stage

Dionisio-Sese & Tobita (2000).stated that the increased content of Na^+ has been reported to suppress the leaf gas exchange and PSII photochemical activity thus negatively affecting carbohydrate accumulation in rice seedlings. Lingle *et al.* (2000). said that the older plants of *Poa pretens* had a higher content of Na^+ , little or no change in Cl^- , and lower content of K^+ than the younger plants. Lopez *et al.* (2002) reported that increased salinity has an inverse relationship with stomatal conductance and net photosynthetic rate resulting in decreased carbohydrate synthesis in Kidney bean plants. Qian *et al.* (2000) conducted greenhouse studies to determine the salt tolerance of 29 zoysiagrass (*Zoysia spp.*). Sodium chloride was gradually added to a basic nutrient solution to obtain salinity level of 42.5 dS m^{-1} Salinity resulted in decreased K^+ and increased Na^+ in shoots of all cultivars. Bos (2001) concluded that *Plantago* species differed widely in their salt tolerance after testing growth and transpiration of *Plantago* species under saline conditions. Suplick *et al.* (2002) said that in salt tolerant turf grass salinity resulted in decreased K^+ and increased Na^+ in shoots of all cultivars. Sodium content was significantly correlated with percentage of leaf firing. Tatura (2004) said that sodium and chloride affect the plants' physiological processes resulting in reduced fresh weight.

REVIEW OF LITERATUR ON VICIA SATIVA

According to Elfawal & El-Nathlawy (1989) germination and seedling characteristics of *Medicago sativa*, *Trifolium alexandrinum*, *Vicia sativa*, barley and Sudan grass (*Sorghum bicolor*) were studied as influenced by 4 concentration of NaCl. For seed germination, *V. sativa*, was the third one in adaptability for the different levels of salinity. The negative influence of NaCl on percentage seed germination and seedling characteristics was significantly high. The rate of seed germination significantly decreased at the highest concentration (15 000 ppm.). Qin (1992) stated that seeds of 4 *V. sativa* cultivars and 2 *V. villosa* cultivars were exposed to temperatures of -2, 20, 40, 60 and 80°C. For all cultivars, seed germination was higher in *V. sativa* than in *V. villosa* and decreased as temperature increased. Temperature had more impact on seed hardness of *V. sativa* than on seed hardness of *V. villosa*. Zhang *et al.* (1992) stated that *Vicia sativa* and *V. villosa* were sown on 11 different dates at 15-d intervals from mid March to mid August at different geographic locations in China. Depending on the site, *V. villosa* and *V. sativa* were cold and drought-tolerant with forage yields of 1.9-4.5 and 2.4-4.5 t/ha, respectively. *Vicia sativa* the pasture crop when sown in spring had higher DM production than when sown in summer. The best cutting dates were after the crop reached full ground cover for 0-30 days after flowering for *V. sativa*. Mermer *et al.* (1994) in his experiment obtained 14 common vetch accessions from various sources tested to

determine their adaptation and production potentials under saline conditions. According to results dry forage and seed yields of cultivars varied between 150-215 kg/day and 64-94 kg/day, respectively. In regard to 50 percent flowering time, no significant difference was observed among the accessions and it changed between 78 and 81 days. By considering earliness, dry forage and seed yields, L-771, L-773 and L-775 accessions were determined as outstanding lines among the others.

SUMMARY OF THE REVIEW

The above review indicates the importance of the grasses included in the study and interest of researchers in view of the multiple uses of the grasses, particularly, in the control of salinity, use of saline land for the production of forage for animals and ultimate uplift of the economic conditions of those depending upon saline habitats. It would further provide a base for the conduct of the present study. On the basis of findings of the studies referred above, a proper rationale was drawn for the present study.

MATERIALS AND METHODS

On the basis of literature referred to in Chapter II, the study was conducted in two phases.

a. Germination and seedling growth Studies in Laboratory

Germination and seedling growth studies were conducted in the Phytocology Lab. in the Department of Botany, University of Peshawar. Certified seeds of *Bothriochloa pertusa*, *Dichanthium annulatum* and *Panicum antidotale* were obtained from Pakistan Forest Institute, Peshawar. Viability of the seeds was tested by tetrazolium test. The glassware was thoroughly washed with tap water followed by rinsing with distilled water. Dried glassware was then sterilized at 170°C for 4 hours prior to use. Ten viable seeds of *Bothriochloa pertusa*, *Dichanthium annulatum*, *Panicum antidotale* and *Vicia sativa* were placed at equal distances in 7 cm petri dishes on twice folded Whatman No. 1 filter paper seedbeds. Each treatment was replicated 10 times. There were three NaCl treatments: 5.0, 10.0 and 15.0dSm^{-1} while the control contained no NaCl. The petridishes were incubated in the incubator at $25\pm 1^{\circ}\text{C}$ for 96 hours. Germination percentage was recorded and total germination was determined after 96 hours. Plumule and radical lengths were recorded in each treatment and average lengths were calculated. Fresh weights of the 20 randomly selected seedlings of the treated and control groups were determined. Seedlings were dried at $65\pm 1^{\circ}\text{C}$ for 72 hours and dry weights were determined. The moisture content

of the seedlings was determined on oven dry bases. The results were subjected to software SPSS and ANOVA by Steel and Toric (1980).

b. Growth Performance Studies in the Field

The pot studies were conducted on 7th November 1999 in the net house of Botany Department, University of Peshawar under natural environmental conditions. The size of the pots was 19x12 cm. There were five replicates for each treatment. Each pot had 5Kg loamy soil lined with double layer of good quality polyethylene bags to avoid salt leaching or seepage of soil solution. The soil was analysed using single HF-decomposition atomic absorption technique (Jackson, 1974) by the Soil Testing Laboratory of Soil Science Department of Agriculture University of Peshawar. The soil used had 8.75% CaCO_3 , 2.6% organic matter, 0.12% nitrogen, 20.9 ppm phosphorus, 413.5 ppm potassium, $1.2 \mu\text{g gm}^{-1}$ copper, $2.2 \mu\text{g gm}^{-1}$ zinc, $3.1 \mu\text{g gm}^{-1}$ iron, $4.0 \mu\text{g gm}^{-1}$ manganese, $200 \mu\text{g gm}^{-1}$ calcium, $305 \mu\text{g gm}^{-1}$ potassium, $216 \mu\text{g gm}^{-1}$ sodium, 7.7 pH level, 0.21dSm^{-1} electrical conductivity, 0.067% total soluble salts, 27.3% clay, 46.0% silt and 26.7% sand. The reaction of the soil was slightly alkaline and it seemed to be calcareous. Organic matter was not deficient and the soil was normal (fertile) for plant growth. EC was measured using saturation extraction method. Distilled water was added to 250 g of air-dried sample until it had the consistency of a thick paste. It was allowed to stand for one hour, the soil water was

extracted under vacuum and the solution was used for measurement of electrical conductivity (Knoxfield, 1995).

The total concentration of soluble salts to total dissolved solids (TDS) was determined as EC using EC-meter expressed as dSm^{-1} . Ten seedlings each of *Panicum antidotale*, *Dichanthium annulatum* and *Bothriochloa pertusa* from the nursery raised and maintained by the Pakistan Forest Institute, Peshawar were planted in pots on 7th November 1999. It took 2 months for the seedlings to restart their maximum possible growth. After one month of the maximum growth of all the test plant species they were cut to the same level. Thinning of all the plants was done with hands very carefully so that other roots might not be injured. Five uniform equidistant and healthy seedlings were left in each pot. Weeds were also removed by hand whenever needed. Four days after thinning, the plants had attained a height of 50 cm, the pots were salinized with calculated amount of NaCl concentration i.e. 0.21 (control), 5.0, 10 and 15 dSm^{-1} . All the pots were brought to the desired salinity levels by providing 5 dSm^{-1} salinity levels in 3 equal increments. Salinity was measured with electrical conductivity meter.

In a pilot study 60 pots were arranged in such a way that 15 pots belonged to salinity level. 0.21 (control), 5, 10 and 15 dSm^{-1} one row of 5 replicates each. Soil with out NaCl served as control. The soil was allowed to saturate at its field capacity.

They were watered with normal tap water whenever needed and protected from excessive rain by polyethylene sheets to avoid drainage of salt.

Various growth parameters were recorded after salt treatment. Survival percentage was recorded first of all. Height of plants, number of tillers after every 30, 60 and 90 days of all the salt treated and control plants was recorded up to the time of harvest. Data for the number of leaves and length of leaves were also recorded. As there was no significant difference in the effects of salinity levels of 5, 10 and 15 dSm⁻¹ the study was limited to salinity level of 10 dSm⁻¹ and the experiment was conducted for the effects of levels (5 cm, 10 cm and 15 cm) and intervals (after one month, two months and three months) of defoliation. At the end of experiment the parts were watered. The soil was removed. The roots were carefully taken out and their length was measured to the nearest possible length (Briske, 2004).

Effect of Simulated Grazing (Defoliation)

Three types of defoliation treatments were given:

1. Plants defoliated at three levels of height i.e. 5, 10 & 15 cm.
2. Plants defoliated at three intervals (intensity i.e. clipping after 1, 2 and 3 months.

When *Panicum antidotale*, *Dichanthium annulatum* and *Bothriochloa pertusa* reached a height of 10-12 inches, 60 pots were separated for each plant species. These 60 pots were grouped into three of 20 pots each. For studying the effect of level of

cutting in 20 pots of each plant species were cut for grazeable biomass at the level of 5 cm, 10 cm and 15 cm. The pots were arranged in such a way that one row of 5 replicates was marked as control. Five replicates were clipped on monthly basis; one row of 5 replicates was clipped after two months of interval/growth, while the 3rd row of 5 replicates was clipped after three months interval.

Height of the plants was measured before clipping and number of tillers was also noted before each cutting. After each cutting fresh weight was measured. The defoliated parts of the plants were oven dried at $65 \pm 1^{\circ}\text{C}$ for 72 hours for dry weight determination. Moisture content was calculated. All the test and control plants were uprooted at the end of experiments. The soil was carefully removed from the roots and then root length was measured with the help of a measuring tap. They were oven dried at 65°C for 72 hours for dry weight determination. Moisture content was calculated as before. Fresh weight of roots was determined. They were oven dried at $65 \pm 1^{\circ}\text{C}$ for 72 hours for dry weight determination. Moisture content was calculated.

Vicia sativa

Certified seeds of *Vicia sativa* were obtained from Pakistan Forest Institute, Peshawar. Viability of the seeds was tested by tetrazolium test. Seeds of *Vicia sativa* were sown in Month of October in pots. The size of the pots was 19x12 cm. There were five replicates for each treatment. Each pot had 5 Kg loamy soil lined with polyethylene bags to avoid salt leaching. There was a control group of 5 replicates,

which was untreated. The soil was analysed using single HF-decomposition atomic absorption technique (Jackson, 1974) by the Soil Testing Laboratory of Soil Science Department of Agriculture University of Peshawar. The soil used had 8.75% CaCO_3 , 2.6% organic matter, 0.12% nitrogen, 20.9 ppm phosphorus, 413.5 ppm potassium, $1.2 \mu\text{g gm}^{-1}$ copper, $2.2 \mu\text{g gm}^{-1}$ zinc, $3.1 \mu\text{g gm}^{-1}$ iron, $4.0 \mu\text{g gm}^{-1}$ manganese, $200 \mu\text{g gm}^{-1}$ calcium, $305 \mu\text{g gm}^{-1}$ potassium, $216 \mu\text{g gm}^{-1}$ sodium, 7.7 pH level, 0.21dSm^{-1} electrical conductivity, 0.067% total soluble salts, 27.3% clay, 46.0% silt and 26.7% sand. Organic matter was not deficient and the soil was normal (fertile) for plant growth.

Within 25 days the maximum possible germination was completed in all the treatments. The seedlings were thinned to 5 individuals/pot after one month of the maximum growth for each species. Uniform equidistant and healthy seedlings were left in each pot.

The height of the plants and the number of branches was measured on fortnight bases. Various other growth parameters such as the number of leaves and leaf length, number of flowers, inflorescence, fruits/pods and the length of pod were recorded after 40 days of the salt treatment and at the time of harvest. Weekly data for the plant survival was also recorded after salt treatment. There were abundant cowpea

aphids on the terminal parts of the plants, which were exterminated with the help of DDT.

The length of the pod, the length of the roots and the number of seeds, weight of the seeds, weight of the husk, weight of the pod, weight of 1000 seeds and weight of the roots were measured at the end of experiment and compared with those of the control plants. Plants were uprooted in the last week of March 2000. The soil was carefully removed from the roots and then root length was measured with the help of a measuring tap. They were oven dried at 65 °C for 72 hours for dry weight determination. Moisture content was calculated as before.

Twenty fruits were randomly selected from each treatment for every species to determine the average number of seeds per fruit. One thousand seeds weight was determined per treatment. Average weight of the seeds and husk per fruit per plant was determined. Number of nodules per plant was noted. The data was subjected to statistical analysis and effect of salinity and clipping on treated and non-treated plants were compared.

Chemical evaluation of plants

Chemical evaluation of some selected treated plants was done. The dried plant samples were powdered using electric grinder and stored for chemical analysis (Reuter and Robinson, 1986). Generally there are two methods used for analysis of plant tissue:

1. Wet digestion.
2. Dry Ashing

These two methods are used for sample preparation in the determination of many elements in plant tissue. The analytical procedure followed was wet digestion. The main advantage of this method is that it eliminates elemental loss by volatilisation because the digestion takes place at low temperature. Dry ashing was not followed for sample preparation because it cannot be used for the determination of elements that are volatile below the ashing temperature. Nonetheless, to be more sure, some solutions were prepared by dry ashing method but the concentration of various elements was low than those prepared by wet method. Hence, the wet method was essentially used.

Preparation Of Plants Samples:

The dried plant samples were powdered with the help of an electric grinder and the samples were stored in plastic bags for all further analysis (Reuter and Robinson, 1986).

One gram of ground dried plant sample was taken and placed in a small beaker. 10ml of concentrated HNO_3 was added and allowed to stand overnight. It was then heated carefully on a hotplate until the production of red NO_2 fumes ceased. After cooling the beaker, a small amount (2-4 ml) of 70% HClO_4 was added. It was

heated again and was allowed to evaporate to a small volume (1-2 ml). The sample material was transferred to a 50 ml flask and diluted with distilled water.

All the samples were prepared by the above method and run on the Perkin Elmer 3300 Atomic Absorption equipped with HGA-600 Graphite furnace. The standardization of machine was done on the locally prepared standards by using the following parameters for each element. The results were verified by the certified standards and the results obtained were within the confidence level of 90%.

Analysis

Using the conditions listed in the "Standard Conditions" section, the concentrations of the elements of interest were determined. Standards were prepared by suitable dilution of the stock standard solutions described under the standard conditions for each element.

To overcome potential anionic interferences when determining calcium and magnesium, the final sample dilution was done and all standards and blanks should contain 1% (w/v) lanthanum. Data were analysed and processed by subjecting it to Microsoft Excel, Minitab 13.2 and SPSS package.

Proximate Analysis

Dry Matter (DM%)

Dry matter was obtained by oven drying the sample at 65 C for 72 hours (Association of Official Analytical Chemists, AOAC, 1984) and percent dry matter

was calculated by following equation:

$$\text{Dry Matter \%} = \frac{\text{Weight of dried sample}}{\text{Weight of fresh sample}} \times 100$$

Ash Contents

One to two gram of plant sample were ignited in Muffle furnace at 550-600 C for at least 8 hours and ash contents of samples were determined (AOAC, 1984) as follows:

$$\text{Ash \%} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100$$

Organic Matter

Organic matter is the portion of the sample, which contains Carbon, Hydrogen, Oxygen, and Nitrogen bonding (Galyean, 1985).

Dry Ashing

Dry ashing can be used for sample preparation in the determination of sodium, potassium, calcium, magnesium, copper, manganese, and iron in plant tissue. It may also be applicable to other elements. A weighed amount of plant material is placed in a crucible and digested (ashed) by heating it in a muffle furnace for several hours. The ash residue is then dissolved in an acid solution, filtered and diluted to a specific volume. Dry ashing provides good precision and is an easy, rapid digestion method requiring minimal analyst attention. An additional benefit is that this method is

relatively free from reagent contamination. The main disadvantage of this procedure is that it cannot be used for the determination of elements that are volatile below the ashing temperature. The vessels used for ashing range from porcelain to platinum dishes. The sample weight used is between 0.5 and 2.0 g depending on the expected concentrations of the elements to be determined. The temperature used for ashing ranges from 475°C to 600°C , and the time given from 4 to 12 hours depending on the sample weight and sample type. The ash residue is usually dissolved in a nitric or hydrochloric acid solution and diluted to volume with deionised water. When determining calcium and magnesium, the final sample dilution should contain 1% lanthanum to overcome potential anionic interferences. An alcohol- H_2O mixture is sometimes used to dilute the sample to an appropriate volume. This can provide an increase in sensitivity for some elements. If the concentration of the element of interest is too low, the metal can be complexed and extracted into an organic solvent such as MIBK to increase its concentration.

TYPICAL ANALYTICAL PROCEDURE

Sample Preparation

One gram dried, ground plant tissue was weighed and placed in a porcelain crucible. It was placed in a cool muffle furnace and ash at 500C overnight. The ash was cooled and dissolved in 5-ml of 20 % HCl, warming the solution, if necessary, to dissolve the residue. The solution was filtered through an acid – ashed filter paper into a 50-ml volumetric flask. The solution was diluted to volume with deionised water and mixed well.

Instrumental Conditions

Mode: Atomic Absorption

Table 1. Atomic Absorption Model: Perkin Elmer 3300.

Element	Wave length (nm)	Energy	Flame type	Oxide flow (L/min)	Fuel flow (L/min)	Lamp current (mA)	Slit width
Fe	248.3	42	Air/C ₂ H ₂	10.0	2.0	30	0.2
Mn	279.5	49	Air/C ₂ H ₂	10.0	2.0	20	0.2
Ca	422.7	50	Air/C ₂ H ₂	10.0	3.8	10	0.7
Mg	285.2	53	Air/C ₂ H ₂	10.0	2.0	6.0	0.7
Na	589	52	Air/C ₂ H ₂	10.0	2.0	8.0	0.2
K	766.5	55	Air/C ₂ H ₂	10.0	2.0	12	0.7
Cu	324.8	53	Air/C ₂ H ₂	10.0	2.0	15	0.7
Zn	213.9	36	Air/C ₂ H ₂	10.0	2.0	15	0.7

RESULTS AND DISCUSSION

LABORATORY EXPERIMENTS

a. Effect on % germination of the grasses

Percent germination under various levels of salinity of the three grasses can be seen in Table 2.

Table 2. Effects of various levels of NaCl (dSm^{-1}) salinization on the average germination % of three grasses under laboratory condition. Each value is a mean of 10 replicates, each with 10 seeds.

Species	Control	Salinity (dSm^{-1}) levels		
		5	10	15
<i>Bothriochloa pertusa</i>	65	41	31	15
<i>Dichanthium annulatum</i>	60	48	31	13
<i>Panicum antidotale</i>	92	41	37	17

The data in Table 2 shows the highest average germination in the petridishes without any salt treatment in *Bothriochloa pertusa* followed by salinity level of 5 dSm^{-1} , 10 dSm^{-1} and 15 dSm^{-1} . The data shows that the germination of all the three tested grasses significantly declined even at 5 dSm^{-1} level of treatment and it further decreased with increasing concentration of applied salt. *Bothriochloa pertusa* and *Dichanthium annulatum* appeared to be more inhibited than *Panicum antidotale* at 15 dSm^{-1} . This is in conformity with the study of El-Nathlawy & El-Fawal (1989) who reported reduced

germination and normal seedling growth at increased temperature and increased salt concentration. Priano & Platti (1989) also observed that *Chloris gayana*, *Elytrigia elongate* and *Elytrigia scabrifolia* seeds when treated with EC of 0, 1.4, 10.5, 18.0 dSm^{-1} had reduced germination and biomass production with increasing salinity. The findings are also in conformity with the study of Shadded & Zaidan (1989) who also reported reduced germination under saline treatments. Similar findings for other species have been reported by Hussain *et al.* (1993), Khan *et al.* (1994), Ashraf *et al.* (1989, 1990) and findings of this study are in line with them.

b. Effect on seedling growth

Salinity affects both the establishment and growth of seedlings. It was seen that salinity severely reduced the growth of plumule and radical in all the treatments (Table 3) especially at higher concentrations.

Table 3. Effects of various levels of NaCl (dSm^{-1}) salinization on the seedling growth (mm) in three grasses under laboratory condition. Each value is a mean of 10 replicates, each with 10 seeds.

Species	Control	Salinity (dSm^{-1}) levels		
		5	10	15
<i>Bothriochloa pertusa</i>	35	31	26	19
<i>Dichanthium annulatum</i>	26	24	17	14
<i>Panicum antidotale</i>	35	19	11	5

The findings are in conformity with the study of Ali *et al.* (1992) who reported decreased germination percentage, length and fresh weight of radicals of *Trigonella*

foenum-graecum L. Ilahi & Begum (1981) also observed that germination, radical growth of sunflower declined when salinity levels increased. The findings are also in conformity with the study of Lyra *et al.* (1992) who observed that cultivars of *Sesamum* exhibited decreased germination percentage and rate of germination, vigour, length of plumule and radical decreased with increasing salinity

c. Effect on the length of Plumule

Effects of various levels of salinity on the average length of plumule of the three grasses can be seen in Table 4.

Table 4. Effects of various levels of NaCl (dSm^{-1}) salinization on the average length of plumule (mm) in three grasses under laboratory condition. Each value is a mean of 10 replicates, each with 10 seeds.

Species	Control	Salinity (dSm^{-1}) levels		
		5	10	15
<i>Bothriochloa pertusa</i>	33	26	19	10
<i>Dichanthium annulatum</i>	21	18	10	8
<i>Panicum antidotale</i>	36	25	9	8

Clipson *et al.* (1991) recorded reduced plumule growth of *Linum usitatissimum* at 50 and 150 mM NaCl concentration and this is in line with the findings of this study. Similarly, Khan *et al.* (1994) stated that the germination, radical and plumule growth in *Helianthus annuus* was decreased with an increase in the salinity levels. The present findings also agree with those of Jain, *et al.* (1991) who achieved

decreased germination percentage and declined radical, plumule and total seedling length of *Trigonella foenum-graecum* Linn. at increased salt concentrations.

d. Effects on biomass and moisture contents:

There has been considerable variation in the behaviour of biomass and moisture.

Table 5. Effects of various levels of NaCl (dSm^{-1}) salinization and clipping on the fresh weight, dry weight (grams) and % moisture of seedlings of three grasses.

Salinity dSm^{-1}	Biomass (mg)		
	Fresh weight	Dry weight	% Moisture
<i>Bothriochloa pertusa</i>			
CONTROL	45.50	19.98	127.73
5	39.90	19.00	110.00
10	28.90	18.99	52.18
15	19.90	10.00	99.00
<i>Dichanthium annulatum</i>			
CONTROL	53.6	19.00	182.11
5	46.5	15.50	200.00
10	35.0	10.00	250
15	29.90	9.90	202.02
<i>Panicum antidotale</i>			
CONTROL	47.2	11.00	229.89
5	37.70	10.00	277.00
10	21.00	10.00	110.00
15	20.0	5.00	300.00

contents. However, most studies have concluded that dry mass generally reduces while fresh/ biomass may increase or decrease. It was seen (Table 5) that the fresh and dry weight of all the three grasses significantly declined in all the treatments. The reduction in fresh and dry mass was more severe with the highest level of salinization i.e., 15 dSm⁻¹. The reduction in dry weight was more obvious at 15dSm⁻¹ in all the grasses.

The present findings are in conformity with the study of Lyra *et al.* (1992) who observed that germination percentage; fresh weight and dry mass had declined in *Sesamum* at different salinity levels. This is also in conformity with the study of Naqvi & Mahmood (1994) in which they reported that fresh and dry weight and moisture contents of *Sesbania sesban* seedlings was decreased with increasing levels of sodium chloride; and with the study of Shadded & Zaidan (1989) who while testing the effect of NaCl salinity levels on the germination and seedling growth of *Raphanus sativus* and *Trigonella foenum-graecum* reported reduced seedling water content in both the species. The poor seedling growth was associated with poor moisture content of seedling in the case of *Bothriochloa pertusa* while in other two grasses the seedling moisture showed increase over control. Shadded & Zaidan (1989) have shown that plants have reduced seedlings moisture contents under saline conditions. In our case the highest average fresh and dry mass in the control petridishes without any salt treatment in three grass species *Bothriochloa pertusa*, *Dichanthium annulatum* and *Panicum antidotale* followed by salinity levels 5 dSm⁻¹, 10 dSm⁻¹ and 15 dSm⁻¹. Seedling

exhibited higher moisture content and this might be an adaptive mechanism to overcome a salinity stress.

Effects on *Vicia sativa*

a. Germination

The germination %, radical and plumule growth drastically dwindled under the saline conditions (Table 6). The effects were more severe in 15dSm^{-1} whereby the reduction was 5 times in germination, 11 times in radical growth and 32 times in plumule growth.

Table 6. Effects of various levels of NaCl (dSm^{-1}) salinization on the germination percent, radical growth (mm). growth of plumule, in *Vicia sativa* incubated at 25°C . Each value is a mean of 5 replicates with 10 seeds each.

Parameters	Salinity (dSm^{-1})			
	Control	5	10	15
Germination%	32	30	16	6
Radical length (mm).	11	6	3	1
Plumule length (mm).	16	9	2	0.43

Khan *et al.* (1994) observed decreased radical growth in *Helianthus annuus* with an increase in the salinity levels created by different salts and this is what was achieved in the present study. Younis *et al.* (1987) also observed that application of 0.5% and 1.0% NaCl concentrations decreased the germination of flax, cotton and castor oil seed. Similarly, Ali *et al.* (1988) reported that germination of *Plantago*

ovata decreased when grown in NaCl solution. Zia & Khan (2004) showed that exposure of seeds to salinity and temperature regimes had little effect on viability of seeds. These findings are similar to those of Jain *et al.* (1991) who reported decreased germination percentage and declined radical, hypocotyle and total seedling length of *Trigonella foenumgraecum* Linn. at increased salt concentrations. Nanaiah & Krishnan (1990) reported higher survival rate of the diploid *Solinum viarum* plants at the lowest salinity levels. The plants proved susceptible to high salinity level. Bennett & Richard, (2002) reported salt tolerance limits for some common vegetation, crop and pasture species and termed *Avena sativa*, *Chloris gayana*, *Medicago polymorpha* spp., *Trifolium repens*, and *Triticum aestivum* moderately saline. Shin & Naoki, (2000) conducted growth experiments on differential salt tolerance of two *Artemisia* species *A. stelliriana* and *A. fukudo* growing in contrasting coastal habitats. Germination percent was higher in *A. fukudo* while NaCl reduced the relative growth rate in *A. stelliriana* significantly.

b. Biomass

Mangal *et al.* (1987) reported that the germination, vegetative growth of *Trigonella foenum-graecum* and *Beta vulgaris* decreased when grown in saline conditions. Like grasses, seedling biomass of *Vicia sativa* was also registered low due to applied salinity (Table 7).

Table 7. Effects of various levels of NaCl (dSm^{-1}) salinization on the fresh weight (gm), dry weight (gm) and moisture content in *Vicia sativa* incubated at 25°C . Each value is a mean of 5 replicates with 10 seeds each.

Parameters	Salinity (dSm^{-1})			
	Control	5	10	15
Fresh Weight (gm)	1.0472	1.0370	0.0721	0.0290
Dry Weight (gm)	0.091	0.0750	0.0100	0.0050
% Moisture	98.95	98.96	99.93	99.99

FIELD WORK

The laboratory findings point out that these grasses are susceptible to saline conditions. The poor germination, seedling growth and moisture contents suggest that introduction of these plants might fail in their establishment. However, lab studies in pure salt solution present a highly adverse habitat conditions. It therefore might not be a true simulation of natural condition. Therefore, field studies were conducted using soil to further explore the possibility of their tolerance towards clipping under saline conditions .

A. GRASSES

a. Effects on survival of seedlings

Data on survival of the three grasses under various levels of cutting under saline conditions can be seen in Table 8.

Table 8. Effects of various levels and intervals of clipping on survival percentage of three grasses. Each value is a mean of 5 replicates with five plants each.

Cutting level (cm)	Clipping intervals			
	Control	M ₁	M ₂	M ₃
a. <i>Bothriochloa pertusa</i>				
5	100	100	80	100
10	100	100	100	100
15	100	100	80	80
b. <i>Dichanthium annulatum</i>				
5	100	100	80	80
10	100	80	80	80
15	100	80	80	80
c. <i>Panicum antidotale</i>				
5	100	80	100	80
10	100	100	100	80
15	100	80	80	100

M₁= one month; M₂= two months; M₃= three months and C= Control

The data on *Bothriochloa pertusa* indicate that the survival % in the control groups was 100. At 5cm level, the M₁ and M₃ treatments had survived 100% while in M₂ there was 80% survival. At the 10 cm treatment 100 % survival was recorded for *Bothriochloa pertusa* for all the three intervals of clipping. In 15 cm level of cutting there was 100% survival in M₁ treatment but dropped to 80% in M₂ & M₃ treatments. This indicates that the clipping affected the survival % of *Bothriochloa pertusa*.

The survival % in *Dichanthium annulatum* at all salt and clipping treatments dropped to 80% with the exception of 5cm level and M₁

For *Panicum antidotale*, the data indicate that survival % age in the control groups was 100 % while at 5 cm level and M_1 and M_3 intervals of clipping the survival was 80%. Similarly, at 10 cm level of clipping survival was 100-% at M_1 and M_2 intervals, which dropped to 80% at M_3 . At 15 cm level of clipping, the survival dropped to 80% at M_1 and M_2 interval but remained untouched at M_3 . This also indicated that the cutting level affected the survival rate of *Panicum antidotale*. High concentrations of sodium ions decrease the uptake of calcium, which play important role in the cell division and leads to stunted plant growth and ultimately death of meristematic cells (Shah *et al.* 2004). Plants that have secretory mechanism might survive better. Another efficient desalination mechanism is the removal of older salt laden leaves or stems and the subsequent growth of salt free parts. Marcar *et al.* (2002) suggested low to moderate salinity tolerance in *Melaleuca lanceolata* and *Melaleuca decussata*. while in another study Marcar *et al.*, (2004) reported lowest survival rate and low annual growth rate at 7.5 cm level of cutting in *Quercus macrocarpa* seedling at low salinity. Similarly, Brink (1995) observed significant reduction in survival of Kallargrass due to low height of clipping. Zeng & Michael (2000) observed reduced survival at 1.9dsm^{-1} and reduced seedling growth at 3.4dsm^{-1} in canary grass. Our findings are in line with them.

b. Effect on Tillering.

The data on the effects of levels and intervals of clipping on tillering capacity is given in Table 9 .

Table 9. Effects of various levels and intervals of clipping on the average number of tillers in three grasses. Each value is a mean of 5 replicates with five plants.

Cutting levels (cm)	Clipping Intervals			
	Control	M ₁	M ₂	M ₃
<i>a. Bothriochloa pertusa</i>				
5	6.40	6.40	7.00	8.60
10	7.40	11.40	9.00	8.80
15	9.20	7.80	8.80	6.60
<i>b. Dichanthium annulatum</i>				
5	12.60	13.80	14.40	13.80
10	10.20	9.20	10.20	11.40
15	13.00	10.60	9.40	8.20
<i>c. Panicum antidotale</i>				
5	10.80	14.80	10.00	11.60
10	13.60	15.80	16.80	13.00
15	11.20	13.20	16.00	13.80

M₁= one month; M₂=two months; M₃= three months, C= Control

The data indicate that in certain instances the number of tillers in the control groups of the three grasses is lower than the comparative groups at the same level of cutting (horizontal movement in the Table 9). However, the number of tillers did not vary significantly when the levels of cutting were considered. There were almost no statistical differences in plants clipped at 5cm and 15 cm levels. All the three grasses had almost the same trend showing that the tillering capacity was not much influenced. There was, however, a decline in the average number of tillers with the cutting intervals. The findings are in contradiction to those of Hartnett (1989) who found reduction in tillering after defoliating *Andropogon gerardii* and *Panicum virgatum* grown by rhizome. However, Pitman (1989) showed that *V. adenantha*

spread aggressively and produced production stands more rapidly than *V. parkeri*. Grieve *et al.* (1993) reported a progressive decrease in tillering capacity after grazing of grasses under saline condition. Haferkamp & Karl (1999) observed reduced tiller numbers by clipping vegetative parts of the Japanese brome. Crested wheatgrass is an outstanding example of a grass species that tillers profusely following defoliation (Dahl, 1995). Rates of tiller growth on defoliated plants may occasionally exceed those of non-defoliated plants. In crested wheatgrass, grazed tillers had higher relative growth rates when grazing occurred prior to internode elongation in the spring than tillers of non-grazed plants (Briske & Richards, 1995). The results were partly better as compared to control as these plants may have adaptation to grow under saline conditions. Moreover tolerance mechanism facilitates growth while avoidance mechanism reduces the probability and severity of plant defoliation/salinity while grazing/salinity resistance is the relative ability of plants to survive grazing under saline conditions. It is observed that there was a combination of the two components i.e. resistance and tolerance. Shin & Naoki (2002) reported that NaCl reduced the relative growth in *A. stelliriana* significantly. Mansk (2005) stated that after defoliation carboxylase activity increases in plants that include increased rate of CO₂ conductance and carbohydrate storage.

c. Effect on height

The growth of each plant was noted in each of the treatment each month. The data in the control column of Table 10 is the height of the plants after 3 months. The data in M_1 column is the sum of the lengths cut in the three months. The data in M_2 column is the sum of the length cut after two months plus the length on the 3rd month while the data in M_3 column is the length/height (cm) after three months.

Table 10. Effects of various levels and intervals of clipping on the average height (cm) of three grasses under saline conditions. Each value is a mean of 5 replicates with five plants each.

Cutting levels (cm)	Clipping Intervals			
	Control	M_1	M_2	M_3
<i>a. Bothriochloa pertusa</i>				
5	55	139	110	85
10	57	205	110	69
15	62	127	89	65
<i>b. Dichanthium annulatum</i>				
5	65	139	110	85
10	57	151	110	61
15	62	141	89	63
<i>c. Panicum antidotale</i>				
5	104	138	113	86
10	85	122	104	83
15	101	135	119	84

M_1 = one month; M_2 = two months; M_3 = three months C= Control

The data clearly shows that with the monthly cutting the total growth of the plants have increased. For *Bothriochloa pertusa*, the total growth with monthly cutting was the highest in all the three levels of cutting in their respective categories. In M_1 category, the

growth increased with the increase in the levels of cutting from 5cm to 10 cm but then falls at the 15 cm level of cutting. in M_2 the growth increased at the 15 cm level of cutting and M_3 in the growth decreased at 15 cm level of cutting. The effect of the salt was also seen on comparing the M_3 data with the plants in the control groups of each category. The growth is higher than the control group.

In *Dichanthium annulatum* the total growth for 10cm level was greater than that attained at 5 cm and 15 cm level of cuttings. At M_2 level, the growth falls with increase in the levels of cutting from 5cm to 15 cm. In M_3 plants, 5cm level was the highest.

For *Panicum antidotale*, the same trend was observed. The total growth was greater in M_1 followed by M_2 . The total growth for 5 cm at M_1 , M_2 and M_3 is the highest followed by 15 cm. This shows that the cutting does affect the total growth. Further, the cutting at 5cm level and 15 cm levels almost had the same effect. Trilica & Orodho (1989) stated that protection from heavy grazing for 50 years did not result in any significant increase in height of *O. hymenoides* compared to other plants.

Salt ions affect the growth high concentration of Na^+ ions in the saline soil decreases the uptake of Mg^{++} and Ca^{++} in plants. Mg^{++} is the structural component of chlorophyll and Ca^{++} is the cell wall component. The deficiency of Mg^{++} and Ca^{++} will affect growth of these plants severely (Shah *et al.*, 2004), which may be genetic through salt secreting mechanism. Ca^{++} is an important part of the meristematic cells and its decline will definitely impair growth. The findings agree with Haferkamp &

Karl (1999) who observed reduced leaf heights by clipping vegetative parts of the Japanese brome. Reducing stubble height from 150 mm to 75 mm on a biweekly frequency reduced herbage. Increasing frequency of clipping did not generally affect total biomass. Some inflorescences were produced with even the most severe clipping treatment.

The findings disagree with those of Keng (1990) who found reduced plant height, length of culms and number of culms per plant in *Agropyron smithii* in saline environments. Similarly, Fahnestock & Detling (2000) also found reduction in shoot and leaf length of *Elymus spicatus* and *Pseudoroegneria spicata* under grazing. Clipping the plant increase the carboxylase activity. CO₂ conductance by leaves increases resulting in compensatory photosynthesis (Carbohydrate pool). After clipping minerals start flowing towards the areas of axillary buds and increase the rate of leaf replacement and re-establishing the photosynthetic capacity of the clipped area by the development of photosynthetic tissues. Salt tolerant plants extract water from the saline soil and are not harmed. Defoliation reduces transpirational area of the plant that conserves soil moisture for longer period of time (Biosalinity Awareness Project, 2004). As stated by Paterson & Sim (2000) that defoliation creates a source sink relationship. The upper leafy part of the plant which was a source of food formation became a strong sink and flow of nutrients is continued from other parts of the plant as the places injury are converted into meristematic regions with zone of active cell

division, cell enlargement and cell differentiation. For all these cells food is needed and in this way the lost parts are regenerated. Potential mechanisms contributing to compensatory photosynthesis include increased carboxylase activity, increased leaf conductance to CO₂ and a decrease in feedback inhibition increasing the sink strength (Briske, 2004). These findings are in conformity with the findings of Bisht & Gupta (1988), Machado & Nunez (1989), Grant & Borthran (1991), Hill (1991) and Mullahey *et al.* (1991) who on the basis of their findings have recommended simulated grazing techniques for the evaluation of tropical grasses. Trilica & Orodho (1989) had concluded that protection from heavy grazing for 50 years did not result in any significant increase in the height of *O. hymenoids* compared with other plants and it had no significant effect on cellulose or lignin content in leaves or stem. Similar were the results of Davies & Evans (1990). They explained the causes of faster regrowth after cutting; Cosgrove and White (1990) concluded that this could be the result of a greater number of new shoots ready to begin growth, despite some of the new shoots being damaged by grazing. According to Morrison & Reckle (1995) defoliation enhances the rate of photosynthesis and thus gives better results.

d. Effect on fresh weight

Fresh weights were taken with each cutting. The weights of the M₁ category were summed up for the three cuttings taken on monthly basis. Similarly, the weights of M₂ were summed up. Data on fresh weight can be seen in Table 11

The fresh weights of the grasses, depending on the growth of each species had also increased for respective species with the cuttings. Plants clipped every month increased fresh weights. The total fresh weight of *Bothriochloa pertusa* with monthly cutting was the highest in all the three levels of cutting in their respective categories (Table 11). In M_1 treatment, the fresh weight decreased with the increase in the levels of cutting from 5cm.

Table 11. Effects of various levels and intervals of clipping on the fresh weights (grams) of three grasses. Each value is a mean of 5 replicates with five plants each

Cutting levels (cm)	Clipping Intervals			
	C	M_1	M_2	M_3
a. <i>Bothriochloa pertusa</i>				
5	85	233	132	144
10	179	162	133	72
15	160	124	148	94
b. <i>Dichanthium annulatum</i>				
5	37	282	166	289
10	122	202	117	266
15	158	188	53	80
c. <i>Panicum antidotale</i>				
5	198	206	148	128.
10	283	159	110	117
15	134	123	98	151

C= Control, M_1 = one month; M_2 = two months; M_3 = three months

to 15 cm. This trend is, however, different in M_2 ; it increased and in M_3 , it first decreased and then increased with the higher levels of cutting.

In *Dichanthium annulatum* the total fresh weights for 10cm level of cutting was greater than 5 and 15 cm level of cutting. At M_2 level, the fresh weights with the levels of cutting from 5cm to 15 cm, decreased at 10 cm and 15 cm. Similarly, at M_3 the weights decreased with increase in the levels of cutting from 5 to 15 cm. Ockerby *et al.* (2001) said that defoliation adjusts the biomass and yield potential of the crops.

For *Panicum antidotale*, the same trend was seen. The total fresh weight in the period of three months is greater in M_1 followed by M_2 and M_3 . The total fresh weights for 5 cm at M_1 , M_2 and M_3 is the highest followed by 15 cm. The growth in the fresh weights is the same. This shows that the clipping does affect the total growth in length/ heights and thus the fresh weights of the clipped foliage. According to (Francois & Maas, 1999) toxic ions in the rhizosphere are built-up initially causes injury to plant roots, and then their gradual accumulation in the aerial parts results in heavy damage to plant metabolism, reducing growth and yield. Injury to leaves due to excess ion-accumulation might be an important factor controlling the fresh weight. According to Wahid (2004) salinity reduces water content and water potential of leaves, and when water is not available the plant loses its fresh weight. Aoduriz & Cargano (1989) suggested that to increase the dry mass yield swards should be cut moderately to a height of 4cm.

According to Saleem & Call (1992) after defoliating *Chrysopogon aucheri* and *Cymbopogon jawarnacusa* the shoot biomass of *Chrysopogon aucheri* was more in a four weeks interval than *Cymbopogon jawarnacusa*.

e. Effect on dry weight

The dry weights have the same trend as in the fresh weights. The dry weights depending on the growth of the plants also increased with the frequency of cuttings (Table 12). As with the monthly cutting the total growth of the plants had increased, the dry weights also increased. In *Bothriochloa pertusa* the total dry weight with monthly cutting was the highest in all the three levels of cutting in their respective categories. Bo *et al.* (2004) stated that in the patterns of plants' response to clipping are species specific, and depend on morphological characters of species. Clipping had little effects on biomass allocation in *Cyperus esculentus*; however, root weight fraction increased with increasing clipping frequency. While nutrient availability and clipping frequency had no influence on leaf carbon concentration at harvest, both of them increased leaf nitrogen concentration, and hence reduced leaf C/N ratio. The high concentration of Na^+ or K^+ ions in the saline soil decrease the uptake of Mg^{++} ions which stop many reactions to get completed as Mg^{++} combines with ATP to function in many reactions. Mg^{++} activate many enzymes needed in photosynthesis. Moreover it is an important element of chlorophyll molecule. So the process of carbohydrates formation will decrease/stops altogether. So the fresh and dry weights may decrease

unless there is adaptation or tolerance effect because of the genes for tolerance to salinity. Salt tolerant plants extract water from the salty area or secrete salts through their glands.

Table 12 Effects of various levels and intervals of clipping on the dry weights (grams) of three grasses under saline conditions. Each value is a mean of 5 replicates with five plants each.

Cutting levels (cm)	Clipping Intervals			
	C	M ₁	M ₂	M ₃
<i>a. Bothriochloa pertusa</i>				
5	65	63	47	80
10	131	80	68	22
15	120	66	39	57
<i>b. Dichanthium annulatum</i>				
5	72	65	37	80
10	70	53	26	22
15	114	57	42	57
<i>c. Panicum antidotale</i>				
5	133	44	18	26
10	139	43	19	29
15	127	53	18	31

M₁= one month; M₂= two months; M₃= three months, C= Control

In M₁ category of *Bothriochloa pertusa*, the dry weight increased with the increase in the levels of cutting from 5cm to 10 cm but then declined at the 15 cm level of cutting. The same trend was seen in M₂ and in M₃ categories the dry weight decreased at 10 cm

In *Dichanthium annulatum* the total dry weight for 10cm was lesser than 5 cm and 15 cm levels of cutting. In M₂ and M₃ level, the dry weights falls with increase in the levels of cutting from 5cm to 10 cm. but increased at 15 cm.

For *Panicum antidotale*, the total dry weight was greater in M₁ followed by M₃. The total dry weight for 5 cm at M₁, M₂ and M₃ was the highest followed by 15 cm. This showed that the cutting does affect the dry mass production. The findings agree with those of Hodgson (1990) who reported increased dry weight with increasing rate of defoliation. Brink (1995) studied the growth and morphology of white clover and suggested that close defoliation of white clover during the summer and autumn was detrimental to plant survival. According to (Francois & Maas, 1999). changes in ionic status of green leaves are crucial to adjudge the sustenance of the active photosynthetic canopy in giving higher dry matter yield.

f. Effect on root length

The data in Table 13 indicates that the root length increased with the clipping level and frequency of cutting in each species.

In *Bothriochloa pertusa*, the root lengths decreased while moving horizontally from M₁ to M₃ in the 5 cm and 10 cm levels of cutting. However in 15 cm level of cutting, the lengths increased from M₁ to M₃. in M₂ the length increased at 15 cm level in M₁. In M₂, the length decreased from 5 cm level to 10 cm level and then increased at 15 cm level. in M₃, the lengths increased continuously from 5 cm to 15 cm levels of cuttings.

Table 13. Effects of various levels and intervals of clipping on the root length (cm) of three grasses under saline conditions. Each value is a mean of 5 replicates with five plants each.

Cutting levels(cm)	Clipping Intervals			
	C	M ₁	M ₂	M ₃
<i>a. Bothriochloa pertusa</i>				
5	45	40	37	31
10	34	40	35	37
15	29	30	42	50
<i>b. Dichanthium annulatum</i>				
5	36	35	36	39
10	40	38	32	38
15	58	48	54	55
<i>c. Panicum antidotale</i>				
5	56	41	39	37
10	30	37	38	22
15	55	46	46	39

M₁= one month; M₂= two months; M₃= three months, C= control

In *Dichanthium annulatum*, the length increased from M₁ to M₃ at 15 cm levels of cutting, while at 10 cm levels of cutting, no significant differences were there. When levels of cuttings increased from 5cm to 15cm, it was observed that root length increased at each cutting interval (Table 13)

In *Panicum antidotale*, the lengths decreased from M₁ to M₃ while with increasing the height of clipping level there was an increase in the root lengths. Thornton and Millard (1996) worked on faster growing species *Lolium perenne* and slower grower *Festuca* species, which differed in relation to the rate of recovery of the lost parts due to defoliation and root length. Saleem & Call (1992) claimed that defoliation after 4 weeks interval produced more root biomass in *Chrysopogon acheri* than in

Cymbopogon jawarncusa. Marcum (1999) found that relative root weight increased under saline condition as compared to control. Arredondo & Johnson (1998) evaluated the influence of clipping on root length of 3 range grasses found that specific root length in Hycrest and Whitmar decreased through time while cheatgrass did not exhibit changes in specific root length through time under the influence of clipping.

g. Effect on Fresh weights of roots

Data on fresh weights of roots can be seen in Table 14.

Table 14: Effects of various levels and intervals of clipping on the fresh weights of roots of the three grasses under saline conditions. Each value is a mean of 5 replicates with five plants each.

Cutting levels(cm)	Clipping Intervals			
	C	M ₁	M ₂	M ₃
a. <i>Bothriochloa pertusa</i>				
5	33	20	30	14
10	32	18	20	19
15	32	20	26	18
b. <i>Dichanthium annulatum</i>				
5	72	92	74	61
10	122	42	95	50
15	158	42	45	48
c. <i>Panicum antidotale</i>				
5	40	69	37	61
10	57	56	79	46
15	27	72	80	59

M₁= one month; M₂= two months; M₃= three months, C= Control

In *Bothriochloa pertusa* the fresh weights of roots increased from M₁ to M₂ then decreased at M₃ in all levels of cuttings. In vertically downward movement,

however, the weight decreased for M_1 and M_2 from 5 cm to 10 cm and then increased at 15 cm levels of clipping. In M_3 , the weight declined at 5 cm level compared to 10 and 15 cm levels.

For *Dichanthium annulatum*, the fresh weight of roots decreased at 5 cm levels from M_1 to M_3 all levels of clipping. In downward movement, the fresh weights decreased in M_3 from 5 cm to 15 cm levels. However, in M_1 the weight decreased at 10 cm levels and in M_2 , it increased from 5 to 10 cm levels and then decreased..

In *Panicum antidotale*, the fresh weight of roots at M_2 . 15. was more than the other plants. of the other durations or other levels. In downward movement, i.e. from 5m to 10cm, the weights decreased in M_1 and M_3 and then increased at 15cm. but in M_2 the fresh weights of roots increased from 5cm to 15cm.

h. Effect on the dry weights of roots

Data on dry weights of roots can be seen in Table 15.

In *Bothriochloa pertusa* the weights decreased from M_1 to M_3 at all levels and intervals of clippings intervals except 10 cm level where it increased.

In case of *Dichanthium annulatum*, the dry weights at 5 cm level of cutting at M_1 was highest than any other levels or duration of cuttings while at 10 cm and 15 cm levels of cutting, the weights increased continuously from M_1 to M_3 .

In *Panicum antidotale*, vertically downward movement from 5 cm to 10 cm, however, showed that the dry weights decreased in M₁ and in M₂ and increased at 15 cm level in M₁. In M₃, the dry weights decreased at 10 cm level and then increased at 15 cm level

Table 15. Effects of various levels and interval of clipping on the dry weights (gms). of roots in three grasses under saline conditions. Each value is a mean of 5 replicates with five plants each.

Cutting levels (cm)	Clipping Intervals			
	C	M ₁	M ₂	M ₃
<i>a. Bothriochloa pertusa</i>				
5	27	17	15	11
10	26	14	16	9
15	26	17	14	11
<i>b. Dichanthium annulatum</i>				
5	37	75	49	57
10	70	38	45	47
15	114	32	37	40
<i>c. Panicum antidotale</i>				
5	27	41	22	37
10	28	20	37	28
15	25	32	27	35

M₁= one month; M₂= two months; M₃= three months, C= Control

B. *Vicia sativa*

a. Effect on survival rate, average number of branches and average height

Data on survival rate, average number of branches, and average height of *Vicia sativa* plants under various levels of salinity can be seen in Table 16

Table 16. Effects of various levels of NaCl (dSm^{-1}) salinization on average plant survival of *Vicia sativa*. Each value is mean of 5 plants

Parameter	Control	Salinity dSm^{-1}		
		5	10	15
Survival %	100	84	84	70
Average No. of branches	12	12	9.60	10
Average length (cm)	25.8	32.6	23.4	26.5

Data indicate the salinization effect on average plant survival of *Vicia sativa*. The survival rate decreased with the increasing salinity level. Ayoub (1994) reported that seeds of *Cassia acutifolia* were highly tolerant to salinity and it germinated well but the survival of young plant and total pod yield was significantly reduced in saline soil.

Data on the effect of salinity on the number of branches of *Vicia sativa* also indicate that the number of branches decreased with the increasing level of salinity. Morales *et al.* (1993) reported decreased yield, branching and siliqua/plant in *Brassica juncea* and insignificant effects on 1000 seed weight and seed/siliqua under irrigated saline water. Similarly, data on the average number and average lengths (cm) of *Vicia sativa* indicated the salinization effect.

Boem *et al.* (1994) stated that in *Brassica napus* the plant height, number of seed and pod per plant decreased while, formation of siliqua and seed filling was delayed with salinity above 6.0 dSm^{-1} . Hamada & ElEnany (1994) reported reduced growth rate *Vicia faba* grown in pots under increasing soil salinity up to 160 mM NaCl. Zaheer *et al.* (1994) reported that salinity has retarding effect on shoot length of *Vicia faba* Bardgett *et al.* (1998) demonstrated that defoliation resulted in reduced carbohydrate content in roots in grasses i.e. *Bothriochloa* and *Dichanthium* because of which the weight of the root is affected.

b. Effect on fresh and dry weight of *Vicia sativa*

Data on the effect of salinity on fresh weight of *Vicia sativa* is given in Table 17.

Table 17. Effects of various levels of NaCl (dSm^{-1}) salinization on fresh and dry weight (gms) of *Vicia sativa*. Each value is mean of 5 plants.

Parameter	Control	Salinity dSm^{-1}		
		5	10	15
Fresh weight gms	10.18	11.94	10.50	8.79
Dry weight gms	3.26	4.03	2.47	2.73

Data in Table 17 indicate the salinization effect due to which the fresh as well as the dry weight decreased with increase in the level of salinity. Alonso *et al.* (1999) stated that forage production decreased in saline environments. Bharti & Singh (1994) claimed that the addition of 2 and 10 EC NaCl to the nutrient media increased the leaf fresh weight and dry weight in *Sesamum indicum*.

c. Effect on length of roots, fresh and dry weights of roots of *Vicia sativa*,

Data on the effects of various levels of salinization on the length of roots, fresh and dry weights of roots of *Vicia sativa* is given in Table 18

Table 18. Effects of various levels of salinization on the length of roots, fresh and dry weights of roots of *Vicia sativa*

Parameter	Control	Salinity dSm ⁻¹		
		5	10	15
Length of roots (cm)	21.6	28.0	22.6	19.8
Fresh weight of roots (gms)	1.32	0.50	0.43	0.31
Dry weight of roots (gms)	0.07	0.06	0.17	0.13

Data in Table indicate the salinization effect on the roots also. The length of roots decreases with the increasing level of salinity. Zaheer *et al.* (1994) reported that salinity has retarding effect on root length of *Vicia faba*.

Similarly, the fresh and dry weights have also been affected with the increase in level of salinity. Bharti & Singh (1994) claimed that the addition of 2 and 10 EC NaCl to the nutrient media slightly decreased the fresh weight of the roots of *Sesamum indicum* while Zaheer *et al.* (1994) reported that salinity has retarding effect on root fresh as well as dry weight of *Vicia faba*.

STATISTICAL ANALYSIS

For the purpose of inference, ANOVA was carried out in respect of the above-mentioned data with the help of Minitab programme. Results are presented in the following manner. Unless otherwise stated the term group in the subsequent pages always mean M_1 , M_2 , M_3 and levels mean height of clipping.

Table 19. ANOVA results for the study of growth in height (cm) of *Bothriochloa pertusa*

General Linear Model: Height versus Group, Level

Factor	Type	Levels	Values			
Group	fixed	4	Control	M_1	M_2	M_3
Level	fixed	3	5cm	10cm	15cm	

Analysis of Variance for Height, using Adjusted SS for Tests						
Source	DF	Seq SS	Adj SS	Adj MS	F	P
Group	3	85961.2	85961.2	28653.7	145.54	.000
Level	2	6010.0	6010.0	3005.0	15.26	.000
Group*Level	6	14350.0	14350.0	2391.7	12.15	.000
Error	48	9450.0	9450.0	196.9		
Total	59	115771.2				

Term	Coef	SE Coef	T	P
Constant	97.750	1.811	53.96	0.000
Group				
Control	-39.750	3.137	-12.67	0.000
M_1	59.250	3.137	18.88	0.000
M_2	5.250	3.137	1.67	0.101
Level				
10cm	12.500	2.562	4.88	0.000
15cm	-12.000	2.562	-4.68	0.000
Group*Level				
Control 10cm	-13.500	4.437	-3.04	0.004
Control 15cm	16.000	4.437	3.61	0.001

M1	10cm	35.500	4.437	8.00	0.000
M1	15cm	-18.000	4.437	-4.06	0.000
M ₂	10cm	-5.500	4.437	-1.24	0.221
M ₂	15cm	-2.000	4.437	-0.45	0.654
Least Squares Means for					
<u>Group</u>		<u>Mean</u>	<u>SE Mean</u>		
Control		58.00	3.623		
M1		157.00	3.623		
M ₂		103.00	3.623		
M ₃		73.00	3.623		
<u>Level</u>					
10cm		110.25	3.137		
15cm		85.75	3.137		
5cm		97.25	3.137		
<u>Group*Level</u>					
Control	10cm	57.00	6.275		
Control	15cm	62.00	6.275		
Control	5cm	55.00	6.275		
M1	10cm	205.00	6.275		
M1	15cm	127.00	6.275		
M1	5cm	139.00	6.275		
M2	10cm	110.00	6.275		
M2	15cm	89.00	6.275		
M2	5cm	110.00	6.275		
M3	10cm	69.00	6.275		
M3	15cm	65.00	6.275		
M3	5cm	85.00	6.275		

From the ANOVA Table, the value of P ($P < 0.001$) of interaction Group (Control, M₁, M₂, M₃) and Levels (5cm, 10cm, 15cm) shows that there is a significant interaction between Groups and Levels. Furthermore, $P < 0.001$ of Groups and Levels show that the main effects of Groups and Levels are also significant. The mean height of *Bothriochloa pertusa* at M₁ (Group) and 10cm (Level) was 205, which is very high than other interaction of Groups and Levels. So the height of *Bothriochloa pertusa* at

cutting and salinity level of 10cm with cutting duration of one month (M_1) is much higher than other cutting and salinity levels with different durations. These findings have been highlighted in the Figure

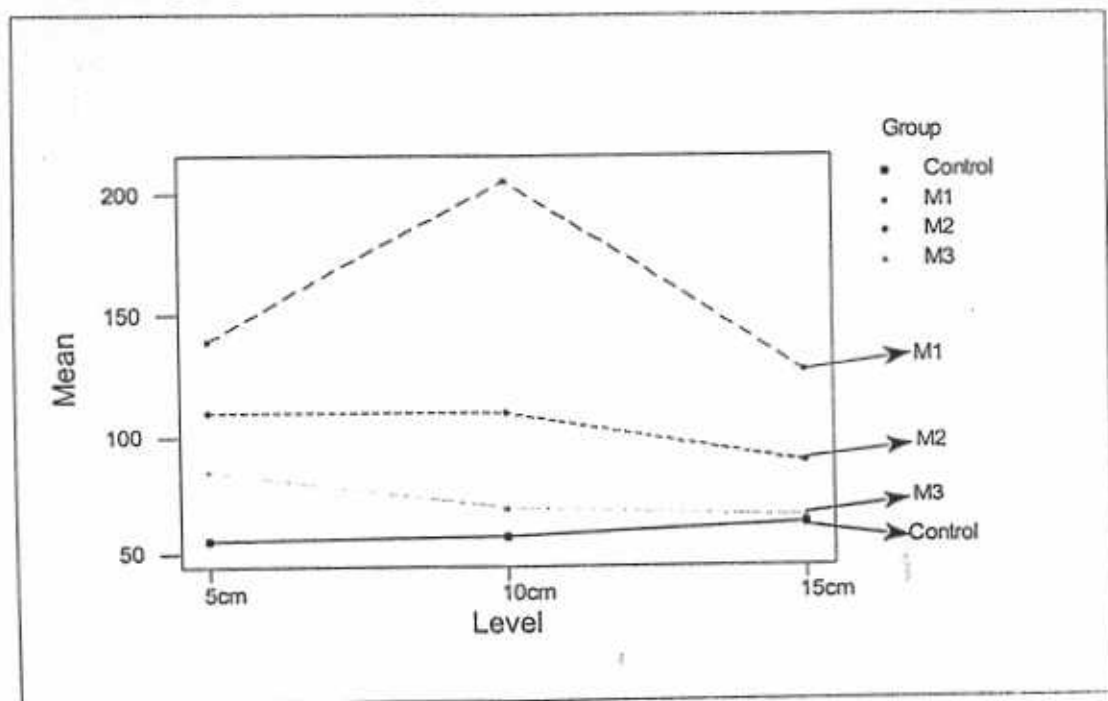


Fig.1. The interactions of groups and levels for height of *Bothriochloa pertusa*.

The significant interaction is indicated by the lack of parallelism of the lines on interaction Fig. 1 shows that the mean height of *Bothriochloa pertusa* is greater at cutting and salinity level of 10cm and the cutting duration of one month (M_1). Thus the height of *Bothriochloa pertusa* at cutting level 10cm with one-month duration increased than other interactions. From botanical point of view, cutting of grasses on monthly basis at 10cm level triggered the rate of compensatory photosynthesis

resulting in Manufacture of more carbohydrates and their accumulation in the storage tissues. Cell division and enlargement process was speeded up at the meristem regions. As a result increased growth rate and greater height was found which indicated that M₁-10 was the best treatment for *Bothriochloa pertusa*.

Table 20. ANOVA results for the study of growth in height (cm) of *Dichanthium annulatum*

General Linear Model: Height versus Group, Level						
Factor	Type	Levels	Values			
Group	fixed	4	Control	M ₁	M ₂	M ₃
Level	fixed	3	5cm	10cm	15cm	
Analysis of Variance for Height, using Adjusted SS for Tests						
Source	DF	Seq SS	Adj SS	Adj MS	F	P
Group	3	63094.6	63094.6	21031.5	74.28	0.000
Level	2	1213.3	1213.3	606.7	2.14	0.128
Group*Level	6	2606.7	2606.7	434.4	1.53	0.187
Error	48	13590.0	13590.0	283.1		
Total	59	80504.6				
Term	Coef	SE Coef	T	P		
Constant	94.417	2.172	43.46	0.000		
Group						
Control	-33.083	3.762	-8.79	0.000		
M1	49.250	3.762	13.09	0.000		
M2	8.583	3.762	2.28	0.027		
Level						
10cm	0.333	3.072	0.11	0.914		
15cm	-5.667	3.072	-1.84	0.071		

Group*Level					
Control	10cm	-4.667	5.321	-0.88	0.385
Control	15cm	6.333	5.321	1.19	0.240
M1	10cm	7.000	5.321	1.32	0.195
M1	15cm	3.000	5.321	0.56	0.576
M2	10cm	6.667	5.321	1.25	0.216
M2	15cm	-8.333	5.321	-1.57	0.124
Least Squares Means for					
Group		Mean	SE Mean		
Control		61.33	4.345		
M1		143.67	4.345		
M2		103.00	4.345		
M3		69.67	4.345		
Level					
10cm		94.75	3.762		
15cm		88.75	3.762		
5cm		99.75	3.762		
Group*Level					
Control	10cm	57.00	7.525		
Control	15cm	62.00	7.525		
Control	5cm	65.00	7.525		
M1	10cm	151.00	7.525		
M1	15cm	141.00	7.525		
M1	5cm	139.00	7.525		
M2	10cm	110.00	7.525		
M2	15cm	89.00	7.525		
M2	5cm	110.00	7.525		
M3	10cm	61.00	7.525		
M3	15cm	63.00	7.525		
M3	5cm	85.00	7.525		

In the above ANOVA Table, the value of P of interaction Group (Control, M₁, M₂, M₃) and Levels (5cm, 10cm, 15cm) is 0.187(P>0.001), which show that there is

an insignificant interaction between Groups and Levels. So there is no interaction effect of Groups and Levels on *Dichanthium annulatum* plant meaning that the effect of group and level is independent. Furthermore, $P=0.128$ ($P>0.001$) of Levels show that there is an insignificant difference between Levels (5cm, 10cm, 15cm) means. So the effect of cutting levels of *Dichanthium annulatum* plant is insignificant. Also the $P=0.000$ ($P<0.01$) of Groups (Control, M_1 , M_2 , M_3), show that there is significant difference between the means. So cutting level and frequency effect on the *Dichanthium annulatum* plant after one, two and three months is significant. But the mean height of *Dichanthium annulatum* plant after cutting one month (M_1) is 143, which is higher than the cutting of two or three months (M_2 or M_3). For further elaboration, the results can be seen in the Fig.2.

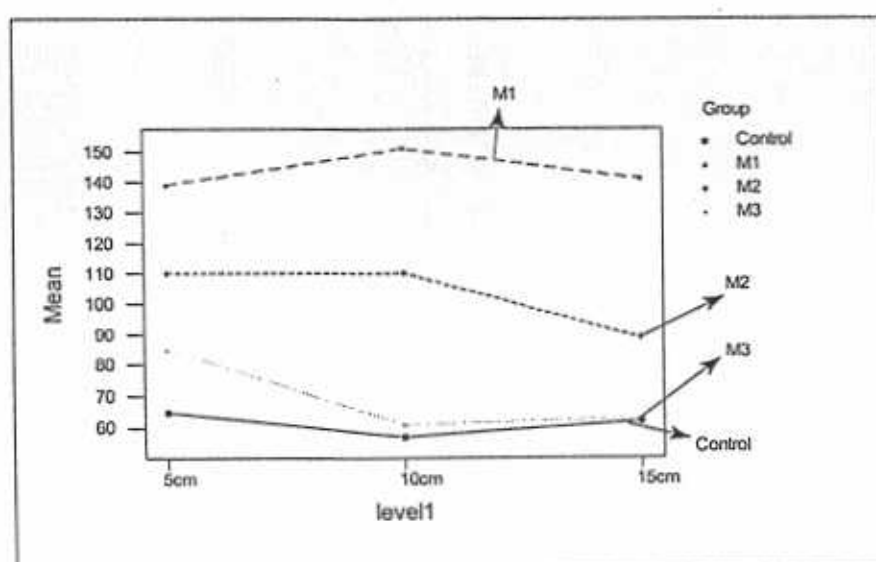


Fig. 2. The interactions of groups and levels for height of *Dichanthium annulatum*.

Fig. 2 shows that the interaction effect of Groups and Levels on *Dichanthium annulatum* plant height is insignificant, which means that the effect of Groups and Levels on *Dichanthium annulatum* plant height is independent. So we construct Main effects plot of Groups and Levels separately as show in Fig.3.

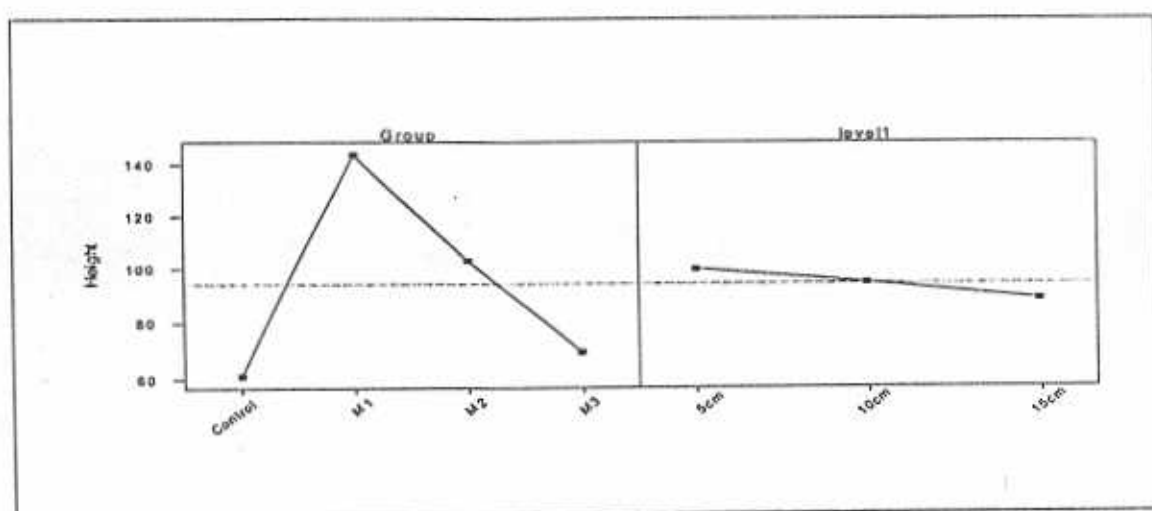


Fig.3 Main effects Plot – data means for height

The above Fig.independently shows the main effect of Groups and levels on *Dichanthium annulatum* plant. The Fig.shows that the mean height of *Dichanthium annulatum* plant at different level is insignificant, meaning that they have same mean at 5cm, 10cm and 15cm cutting and salinity levels. And the mean height of *Dichanthium annulatum* plant at different Groups is significant, showing that the mean height of *Dichanthium annulatum* plant is different after cutting of one month, two months and

three months. But mean height of *Dichanthium annulatum* plant after cutting of one month is 143, which is higher than the cutting after two and three months.

Table 21. ANOVA results for the study of growth in height (cm) of *Panicum antidotale*.

General Linear Model: Height versus Group, Level

Factor	Type	Levels	Values			
Group	fixed	4	Control	M ₁	M ₂	M ₃
Level	fixed	3	5cm	10cm	15cm	

Analysis of Variance for Height, using Adjusted SS for Tests						
Source	DF	Seq SS	Adj SS	Adj MS	F	P
Group	3	18768.3	18768.3	6256.1	35.79	0.000
Level	2	1765.8	1765.8	882.9	5.05	0.010
Group*Level	6	594.2	594.2	99.0	0.57	0.755
Error	48	8390.0	8390.0	174.8		
Total	59	29518.3				

Term	Coef	SE Coef	T	P
Constant	106.167	1.707	62.20	0.000
Group				
Control	-9.500	2.956	-3.21	0.002
M1	25.500	2.956	8.63	0.000
M2	5.833	2.956	1.97	0.054
Level				
10cm	-7.667	2.414	-3.18	0.003
15cm	3.583	2.414	1.48	0.144
Group*Level				
Control 10cm	-4.000	4.181	-0.96	0.343
Control 15cm	0.750	4.181	0.18	0.858
M1 10cm	-2.000	4.181	-0.48	0.635
M1 15cm	-0.250	4.181	-0.06	0.953
M2 10cm	-0.333	4.181	-0.08	0.937
M2 15cm	3.417	4.181	0.82	0.418

Least Squares Means for		
Group	Mean	SE Mean
Control	96.67	3.414
M1	131.67	3.414
M2	112.00	3.414
M3	84.33	3.414
Level		
10cm	98.50	2.956
15cm	109.75	2.956
5cm	110.25	2.956
Group*Level		
Control 10cm	85.00	5.913
Control 15cm	101.00	5.913
Control 5cm	104.00	5.913
M1 10cm	122.00	5.913
M1 15cm	135.00	5.913
M1 5cm	138.00	5.913
M2 10cm	104.00	5.913
M2 15cm	119.00	5.913
M2 5cm	113.00	5.913
M3 10cm	83.00	5.913
M3 15cm	84.00	5.913
M3 5cm	86.00	5.913

According to the ANOVA Table the value of P of interaction Group (Control, M₁, M₂, M₃) and Levels (5cm, 10cm, 15cm) is 0.755 ($P > 0.001$), which shows that there is an insignificant interaction between Groups and Levels. So there is no interaction effect of Groups and Levels on *Panicum antidotale* plant, which means that the effect of group and level is independent. Furthermore, $P = 0.010$ ($P < 0.05$) of Levels show that there is a significant difference between Levels (5cm, 10cm, 15cm) means. So the effect of cutting levels of *Panicum antidotale* plant is significant at 5% level of significant.

$P=0.000$ ($P<0.01$) of Groups (Control, M_1 , M_2 , M_3), which is also show that there is significant difference between means. So cutting level effects in the *Panicum antidotale* plant after one, two and three months is significant. But the mean height of *Panicum antidotale* plant after cutting one month (M_1) is 143, which is higher than the cutting and salinity of two or three month (M_2 or M_3).

For further elaboration, the results have been shown in the Fig.4.

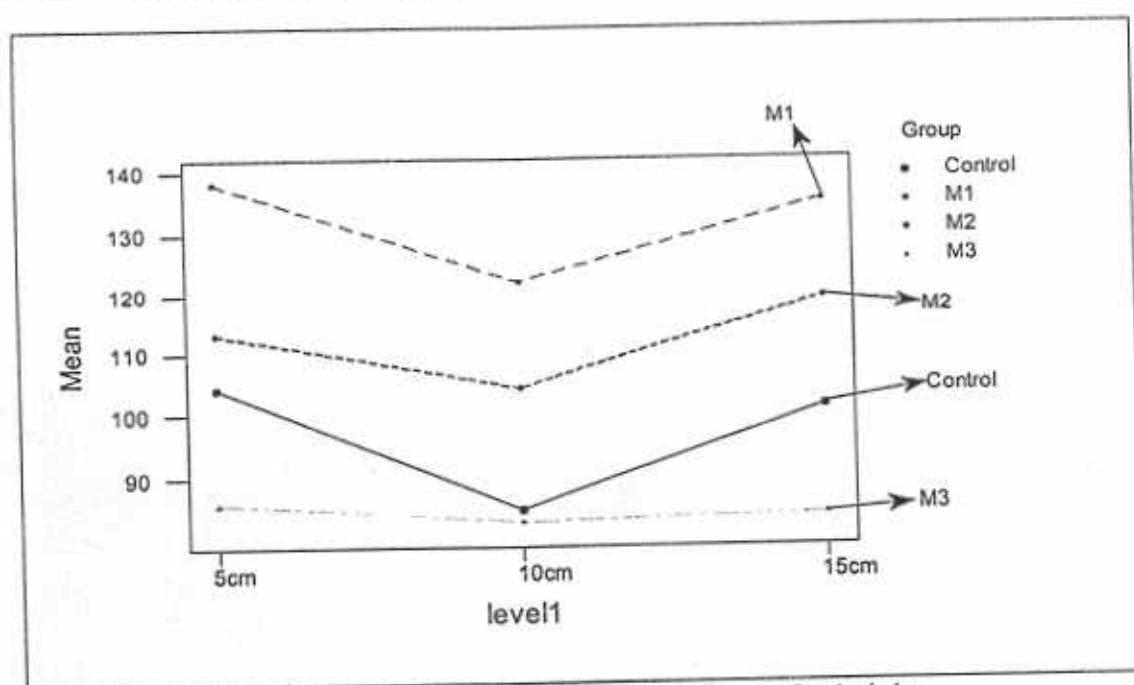


Fig. 4. Interaction plot – data means for height

The insignificant interaction is indicated by the lack of parallelism of the lines on interaction Plot. So Fig. 4.shows that the interaction effect of Groups and Levels on *Panicum antidotale* plant height is insignificant, which means that the effect of Groups

and Levels on *Panicum antidotale* plant height is independent. So we construct Main effect plot of Groups and Levels separately as shown in Fig 5.

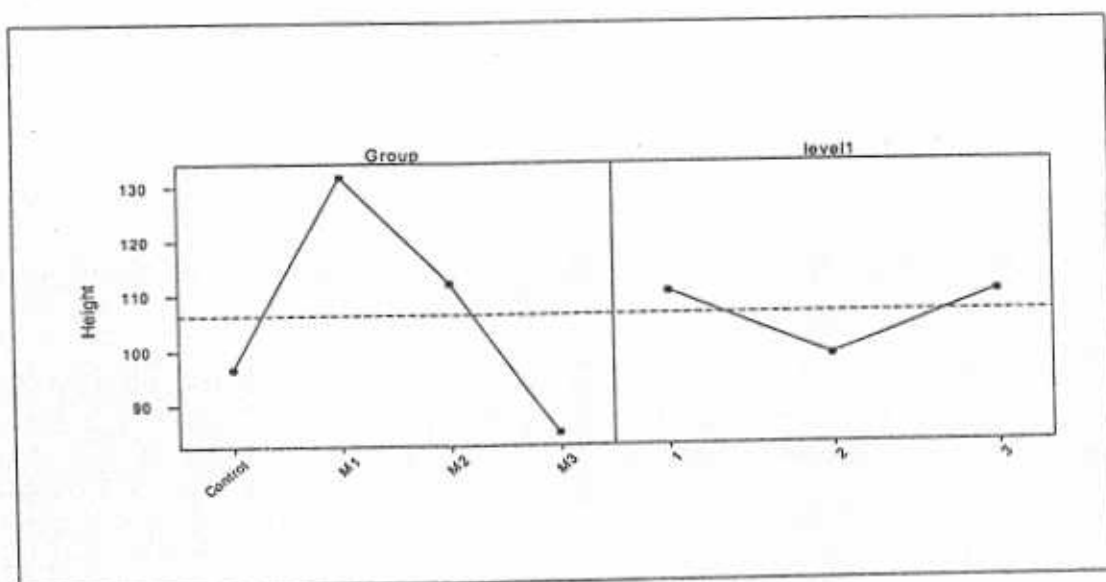


Fig 5. Main effects plot – data means for height

The Fig 5 independently shows the main effect of Groups and levels on *Panicum antidotale* plant. It is clear that the mean height of *Panicum antidotale* plant at different level is significant, indicating that they have different mean at 5cm, 10cm and 15cm cutting and salinity levels. And the mean height of *Panicum antidotale* plant at different Groups is significant, which means that mean height of *Panicum antidotale* plant is different after cutting one month, two months and three months. But mean height of *Panicum antidotale* plant after cutting and salinity of one month is 131, which is higher than the cutting of plant after two and three months.

Table 22 ANOVA results for the study of growth in fresh weight (grams) of *Bothriochloa pertusa*

General Linear Model: Weight versus Group, Level						
Factor	Type	Levels	Values			
Group	fixed	4	Control	M ₁	M ₂	M ₃
Level	fixed	3	5cm	10cm	15cm	
Analysis of Variance for Weight_1, using Adjusted SS for Tests						
Source	DF	Seq SS	Adj SS	Adj MS	F	P
Group	3	36530.7	36530.7	12176.9	21.84	0.000
Level	2	3019.4	3019.4	1509.7	2.71	0.077
Group*Level	6	67038.0	67038.0	11173.0	20.04	0.000
Error	48	26762.0	26762.0	557.5		
Total	59	133350.2				
Term		Coef	SE Coef	T	P	
Constant		138.883	3.048	45.56	0.000	
Group						
Control		2.517	5.280	0.48	0.636	
M1		34.183	5.280	6.47	0.000	
M2		-1.217	5.280	-0.23	0.819	
Level						
10cm		-2.333	4.311	-0.54	0.591	
15cm		-7.283	4.311	-1.69	0.098	
Group*Level						
Control 10cm		40.133	7.467	5.37	0.000	
Control 15cm		26.083	7.467	3.49	0.001	
M1 10cm		-8.733	7.467	-1.17	0.248	
M1 15cm		-41.783	7.467	-5.60	0.000	
M2 10cm		-2.333	7.467	-0.31	0.756	
M2 15cm		17.617	7.467	2.36	0.022	
Least Squares Means for Weight_1						
Group		Mean	SE Mean			
Control		141.40	6.097			
M1		173.07	6.097			
M2		137.67	6.097			
M3		103.40	6.097			

Level			
10cm		136.55	5.280
15cm		131.60	5.280
5cm		148.50	5.280
Group*Level			
Control	10cm	179.20	10.560
Control	15cm	160.20	10.560
Control	5cm	84.80	10.560
M1	10cm	162.00	10.560
M1	15cm	124.00	10.560
M1	5cm	233.20	10.560
M2	10cm	133.00	10.560
M2	15cm	148.00	10.560
M2	5cm	132.00	10.560
M3	10cm	72.00	10.560
M3	15cm	94.20	10.560
M3	5cm	144.00	10.560

According to the analysis of variance (Table 22) the value of P of interaction Group (Control, M₁, M₂, M₃) and Levels (5cm, 10cm, 15cm) is 0.000(P<0.001), which shows that there is a significant interaction between Groups and Levels. Furthermore, P<0.001 of Groups and Levels indicate that main effects of Groups and Levels are also significant. The mean fresh weight of *Bothriochloa pertusa* plant at M₁ (Group) and 5cm(Level) is 233, which is higher than other interaction of Groups and Levels. So the fresh weight of *Bothriochloa pertusa* plant at cutting level of 5cm with cutting with one month (M₁) is much higher than other cutting levels with different durations. This is in line with the study of Hodgson (1990) in which he reported increased tiller density and more leaf area with increasing rate of defoliation in *Bromus*. The fresh weight of a plant is mainly because of the nutrients and cell wall

constituents. The allocation of photosynthate within grasses is consistently altered by defoliation. Flexible pattern of carbon allocation may increase the rate of leaf replacement and re-establishing of carbohydrate manufacturing capacity of grasses, which is the compensatory photosynthesis. After defoliation the non-structural carbohydrate also contribute energy and organic intermediates to the growing points. So the fresh weight of *Bothriochloa pertusa* was more because of monthly cutting (Briske, 2004).

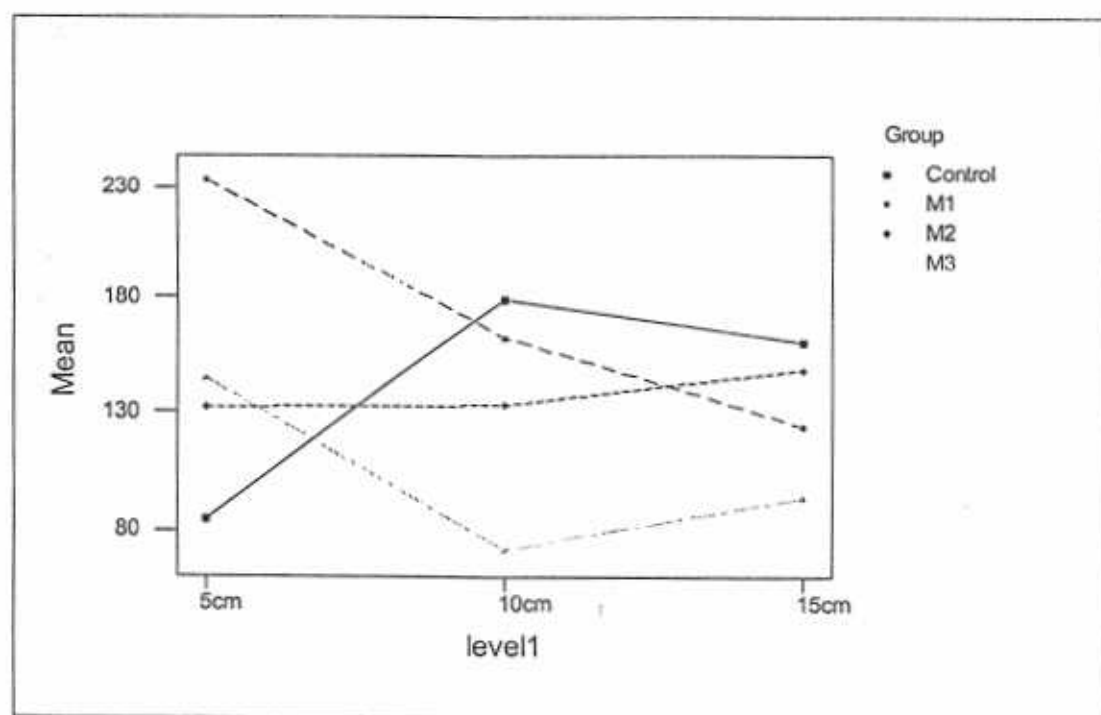


Fig. 6 Interaction plot – data means for fresh weight of *Bothriochloa pertusa*

The significant interaction is indicated by the lack of parallelism of the lines on interaction Plot. Graph shows that the mean fresh weight of *Bothriochloa pertusa*

plant is high at cutting level 5cm and the cutting after one month (M₁). So the fresh weight of *Bothriochloa pertusa* at cutting level 5cm with one-month duration increased more than other interactions.

Table 23. ANOVA results for the study of growth in fresh weight of *Dichanthium annulatum*.

General Linear Model: Weight versus Group, Level						
Factor	Type	Levels Values				
Group	fixed	4		Control	M ₁	M ₂
Level	fixed	3		10cm	15cm	5cm
Analysis of Variance for Weight, using Adjusted SS for Tests						
Source	DF	Seq SS	Adj SS	Adj MS	F	P
Group	3	162378	162378	54126	43.38	0.000
Level	2	73521	73521	36760	29.46	0.000
Group*Level	6	167800	167800	27967	22.41	0.000
Error	48	59896	59896	1248		
Total	59	463594				
Term		Coef	SE Coef	T	P	
Constant		160.833	4.560	35.27	0.000	
Group						
Control		-55.167	7.899	-6.98	0.000	
M1		53.100	7.899	6.72	0.000	
M2		-48.767	7.899	-6.17	0.000	
Level						
10cm		15.817	6.449	2.45	0.018	
15cm		-48.533	6.449	-7.53	0.000	
Group*Level						
Control 10cm		0.52	11.17	0.05	0.963	
Control 15cm		100.87	11.17	9.03	0.000	
M1 10cm		-27.75	11.17	-2.48	0.017	
M1 15cm		-7.80	11.17	-0.70	0.488	
M2 10cm		-11.08	11.17	-0.99	0.326	
M2 15cm		-10.13	11.17	-0.91	0.369	

Least Squares Means for Weight

Group		Mean	SE Mean
Control		105.67	9.121
M1		213.93	9.121
M2		112.07	9.121
M3		211.67	9.121
Level			
10cm		176.65	7.899
15cm		112.30	7.899
5cm		193.55	7.899
Group*Level			
Control	10cm	122.00	15.798
Control	15cm	158.00	15.798
Control	5cm	37.00	15.798
M1	10cm	202.00	15.798
M1	15cm	157.60	15.798
M1	5cm	282.20	15.798
M2	10cm	116.80	15.798
M2	15cm	53.40	15.798
M2	5cm	166.00	15.798
M3	10cm	265.80	15.798
M3	15cm	80.20	15.798
M3	5cm	289.00	15.798

The P value of interaction Group (Control, M₁, M₂, M₃) and Levels (5cm, 10cm, 15cm) is 0.000 ($P < 0.001$), which shows that there is a significant interaction between Groups and Levels. Furthermore, $P < 0.001$ of Groups and Levels indicate that the main effects of Groups and Levels are also significant. The mean fresh weight of *Dichanthium annulatum* plant at M₃ (Group) and 5cm (Level) is 289 gm, which is higher than other interactions of Groups and Levels. So the fresh weight of

Dichanthium annulatum plant at 5cm cutting level with three-month (M_3) duration is much higher than other cutting levels with different durations. In *Dichanthium annulatum* defoliation after three months at 5 cm. level triggered compensatory photosynthesis in the pre-existing photosynthetic tissues. The intercalary meristem of the aboveground parts of the defoliated plant and the apical meristem of the young tillers facilitated growth of the plant and supply of energy and nutrients may be maintained from the nutrient reserves resulting in increased weight of *Dichanthium annulatum*.

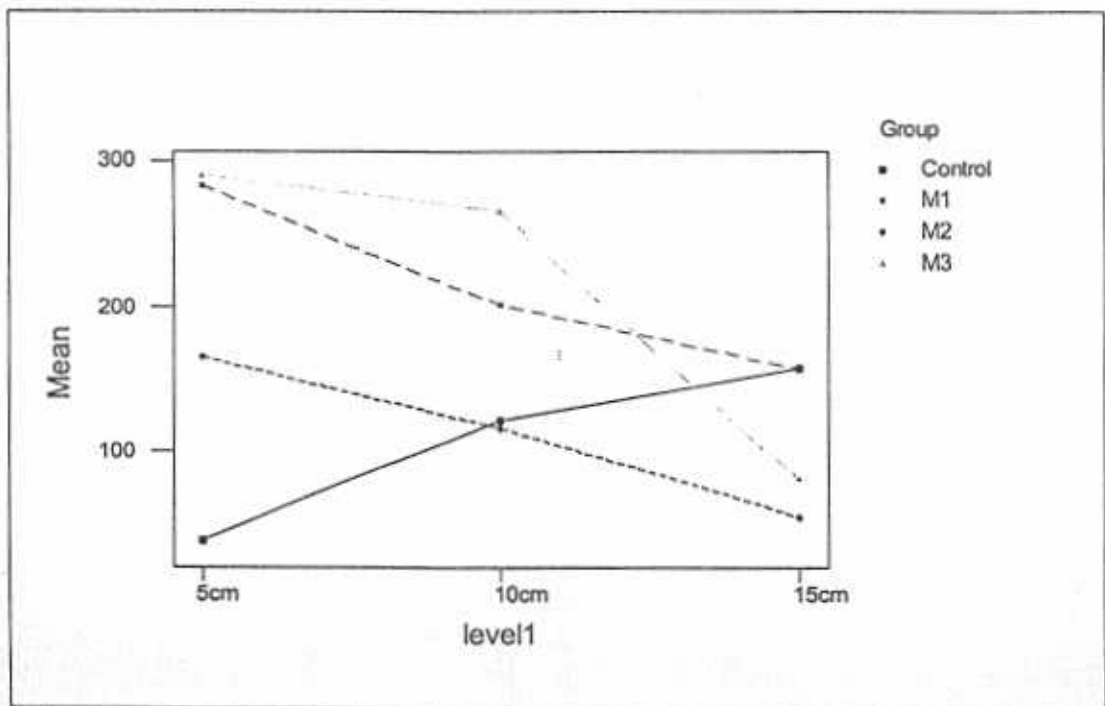


Fig. 7 Interaction plot – data means for fresh weight of *Dichanthium annulatum*.

The significant interaction is indicated by the lack of parallelism of the lines on interaction Plot. Graph shows that the mean fresh weight of *Dichanthium annulatum* plant is high at cutting level 5cm and the cutting after three months (M₃). So the fresh weight of *Dichanthium annulatum* at 5cm cutting level with three-month duration increased than other interactions.

Table 24. ANOVA results for the study of growth in fresh weight of *Panicum antidotale*.

General Linear Model: Weight versus Group, Level						
Factor	Type	Levels	Values			
Group	fixed	4	Control	M1	M2	M3
Level	fixed	3	10cm	15cm	5cm	
Analysis of Variance for Weight, using Adjusted SS for Tests						
Source	DF	Seq SS	Adj SS	Adj MS	F	P
Group	3	66103	66103	22034	63.55	0.000
Level	2	23618	23618	11809	34.06	0.000
Group*Level	6	59443	59443	9907	28.57	0.000
Error	48	16643	16643	347		
Total	59	165806				
Term	Coef	SE Coef	T	P		
Constant	154.617	2.404	64.32	0.000		
Group						
Control	50.450	4.164	12.12	0.000		
M1	7.983	4.164	1.92	0.061		
M2	-35.950	4.164	-8.63	0.000		
Level						
10cm	12.683	3.400	3.73	0.001		
15cm	-28.017	3.400	-8.24	0.000		
Group*Level						
Control 10cm	65.450	5.888	11.12	0.000		

Control	15cm	-42.850	5.888	-7.28	0.000
M1	10cm	-16.483	5.888	-2.80	0.007
M1	15cm	-11.583	5.888	-1.97	0.055
M2	10cm	-21.350	5.888	-3.63	0.001
M2	15cm	7.350	5.888	1.25	0.218

Least Squares Means for Weight

Group		Mean	SE Mean
Control		205.07	4.808
M1		162.60	4.808
M2		118.67	4.808
M3		132.13	4.808
Level			
10cm		167.30	4.164
15cm		126.60	4.164
5cm		169.95	4.164
Group*Level			
Control	10cm	283.20	8.327
Control	15cm	134.20	8.327
Control	5cm	197.80	8.327
M1	10cm	158.80	8.327
M1	15cm	123.00	8.327
M1	5cm	206.00	8.327
M2	10cm	110.00	8.327
M2	15cm	98.00	8.327
M2	5cm	148.00	8.327
M3	10cm	117.20	8.327
M3	15cm	151.20	8.327
M3	5cm	128.00	8.327

The ANOVA results indicate that the P value of interaction Group (Control, M₁, M₂, M₃) and Levels (5cm, 10cm, 15cm) is 0.000 ($P < 0.001$), which means that there is a significant interaction between Groups and Levels. Furthermore, $P < 0.001$ of Groups and Levels indicate that the main effects of Groups and Levels are also significant. The

mean fresh weight of *Panicum antidotale* plant at Control (Group) and 10cm(Level) is 283, which is higher than the other interaction of Groups and Levels. So the fresh weight of *Panicum antidotale* plant at 10cm cutting level with there is no cutting is much higher than other cutting levels with different durations.

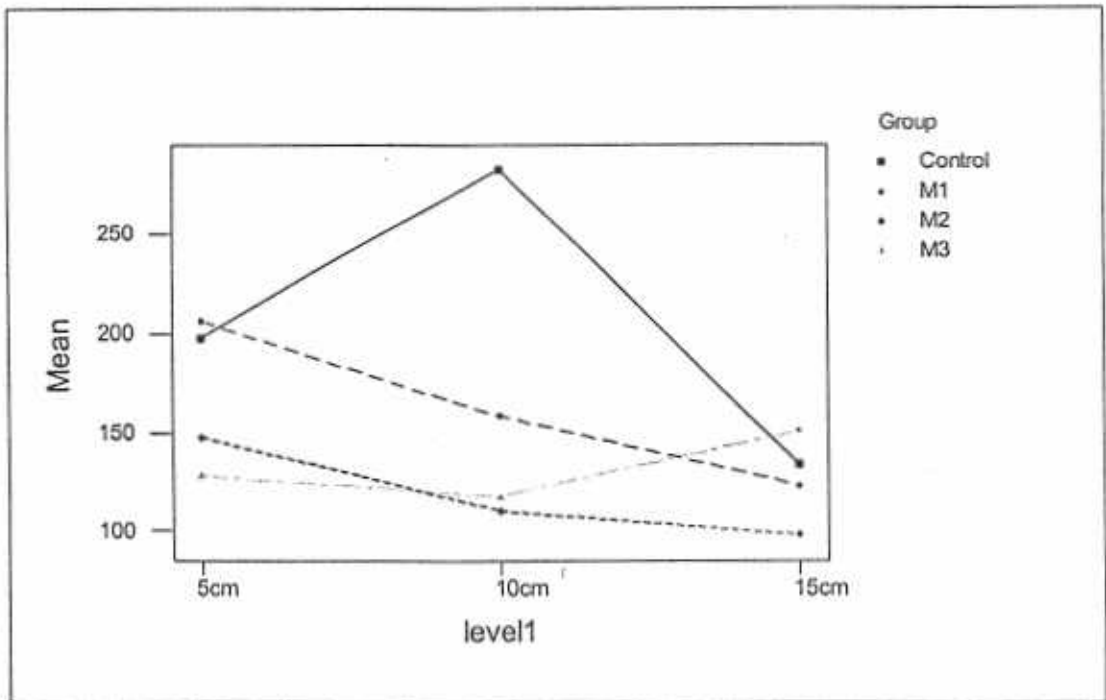


Fig.8 Interaction plot – data means for weight of *Panicum antidotale*

The significant interaction is indicated by the lack of parallelism of the lines on interaction Plot. Fig.8 shows that the mean fresh weight of *Panicum antidotale* plant is high at 10cm cutting level and there is no cutting (Control). So the fresh weight of *Panicum antidotale* at 5cm cutting level with no cutting in Control increased than other interactions. Hill (1991) showed that *Trifolium* species accumulated, more herbage,

from frequent defoliation. In case of other species infrequent defoliation increased herbage accumulation.

Table 25. ANOVA results for the study of growth in dry weight of *Bothriochloa pertusa*

General Linear Model: Weight versus Group, Level						
Factor	Type	Levels	Values			
Group	fixed	4	Control M ₁ M ₂			
M ₃						
Level	fixed	3	10cm 15cm 5cm			
Analysis of Variance for Weight, using Adjusted SS for Tests						
Source	DF	Seq SS	Adj SS	Adj MS	F	P
Group	3	28183.5	28183.5	9394.5	52.57	0.000
Level	2	1335.8	1335.8	667.9	3.74	0.031
Group*Level	6	22692.4	22692.4	3782.1	21.16	0.000
Error	48	578.4	8578.4	178.7		
Total	59	60790.2				
Term	Coef		SE Coef	T	P	
Constant	69.783		1.726	40.43	0.000	
Group						
Control	35.417		2.989	11.85	0.000	
M1	-0.117		2.989	-0.04	0.969	
M2	-18.517		2.989	-6.19	0.000	
Level						
10cm	5.417		2.441	2.22	0.031	
15cm	0.667		2.441	0.27	0.786	
Group*Level						
Control 10cm	20.183		4.227	4.77	0.000	
Control 15cm	13.933		4.227	3.30	0.002	
M1 10cm	4.917		4.227	1.16	0.251	
M1 15cm	-4.333		4.227	-1.03	0.310	
M2 10cm	11.317		4.227	2.68	0.010	
M2 15cm	-12.933		4.227	-3.06	0.004	

Least Squares Means for Weight

Group		Mean	SE Mean
Control		105.20	3.452
M1		69.67	3.452
M2		51.27	3.452
M3		53.00	3.452
Level			
10cm		75.20	2.989
15cm		70.45	2.989
5cm		63.70	2.989
Group*Level			
Control	10cm	130.80	5.979
Control	15cm	119.80	5.979
Control	5cm	65.00	5.979
M1	10cm	80.00	5.979
M1	15cm	66.00	5.979
M1	5cm	63.00	5.979
M2	10cm	68.00	5.979
M2	15cm	39.00	5.979
M2	5cm	46.80	5.979
M3	10cm	22.00	5.979
M3	15cm	57.00	5.979
M3	5cm	80.00	5.979

In the above ANOVA Table the P value of interaction Group (Control, M₁, M₂, M₃) and Levels (5cm, 10cm, 15cm) is 0.000(P<0.001), which shows that there is a significant interaction between Groups and Levels (Table 25). Furthermore, P<0.001 of Groups and Levels shows that the main effects of Groups and Levels are also significant. The mean dry weight of *Bothriochloa pertusa* at Control (Group) and 10cm(Level) is 130, which is very high than other interaction of Groups and Levels. So the dry weight of *Bothriochloa pertusa* at 10cm cutting level with no cutting duration

(Control) is much higher than other cutting levels with different durations. These results have been shown in the plot for further elaboration Fig. 9.

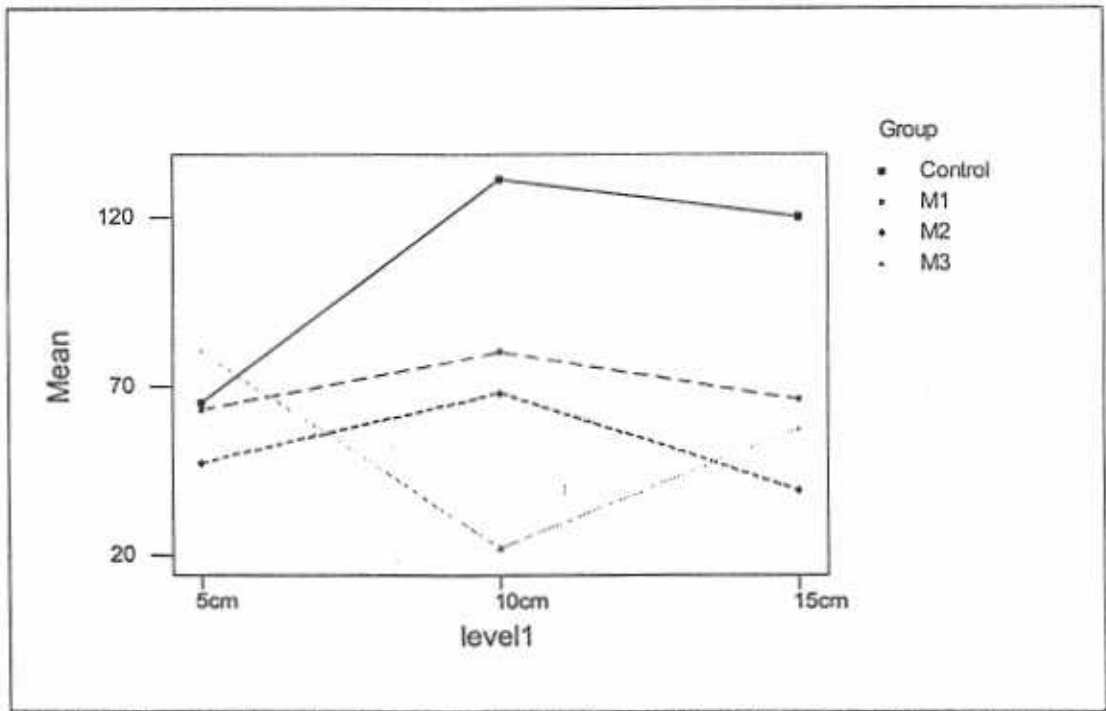


Fig. 9 Interaction plot – data means for dry weight of *Bothriochloa pertusa*.

The significant interaction is indicated by the lack of parallelism of the lines on interaction Plot. Fig.9 shows that the mean dry weight of *Bothriochloa pertusa* is highest at 10cm cutting level and with no cutting (Control). So the dry weight of *Bothriochloa pertusa* at 10cm cutting and salinity level with no duration increased more than other interactions.

Table 26. ANOVA results for the study of growth in dry weight of *Dichanthium annulatum*.

General Linear Model: Weight versus Group, Level						
Factor	Type	Levels	Values			
Group	fixed	4	Control M1 M2 M3			
Level	fixed	3	10cm 15cm 5cm			
Analysis of Variance for Weight, using Adjusted SS for Tests						
Source	DF	Seq SS	Adj SS	Adj MS	F	P
Group	3	19628.6	19628.6	6542.9	49.58	0.000
Level	2	7149.1	7149.1	3574.5	27.09	0.000
Group*Level	6	8719.7	8719.7	1453.3	11.01	0.000
Error	48	6334.0	6334.0	132.0		
Total	59	41831.4				
Term		Coef	SE Coef	T	P	
Constant		57.900	1.483	39.04	0.000	
Group						
Control		27.500	2.569	10.71	0.000	
M1		0.433	2.569	0.17	0.867	
M2		-22.967	2.569	-8.94	0.000	
Level						
10cm		-15.250	2.097	-7.27	0.000	
15cm		9.700	2.097	4.63	0.000	
Group*Level						
Control 10cm		-0.150	3.633	-0.04	0.967	
Control 15cm		19.100	3.633	5.26	0.000	
M1 10cm		9.917	3.633	2.73	0.009	
M1 15cm		-10.833	3.633	-2.98	0.004	
M2 10cm		6.117	3.633	1.68	0.099	
M2 15cm		-2.633	3.633	-0.72	0.472	

Least Squares Means for Weight

Group		Mean	SE Mean
Control		85.40	2.966
M1		58.33	2.966
M2		34.93	2.966
M3		52.93	2.966
Level			
10cm		42.65	2.569
15cm		67.60	2.569
5cm		63.45	2.569
Group*Level			
Control	10cm	70.00	5.137
Control	15cm	114.20	5.137
Control	5cm	72.00	5.137
M1	10cm	53.00	5.137
M1	15cm	57.20	5.137
M1	5cm	64.80	5.137
M2	10cm	25.80	5.137
M2	15cm	42.00	5.137
M2	5cm	37.00	5.137
M3	10cm	21.80	5.137
M3	15cm	57.00	5.137
M3	5cm	80.00	5.137

In the ANOVA table 26 shows that there is a significant interaction between Groups and Levels. Furthermore, $P < 0.001$ of Groups and Levels indicate that the main effects of Groups and Levels are also significant. The mean dry weight of *Dichanthium annulatum* plant at Control (Group) and 15cm(Level) is 114, which is higher than other interaction of Groups and Levels. Thus the dry weight of *Dichanthium annulatum* plant at 15cm cutting and salinity level with no cutting (Control) is much higher than other

cutting and salinity levels with different durations. The results have been further elaborated in Fig.10

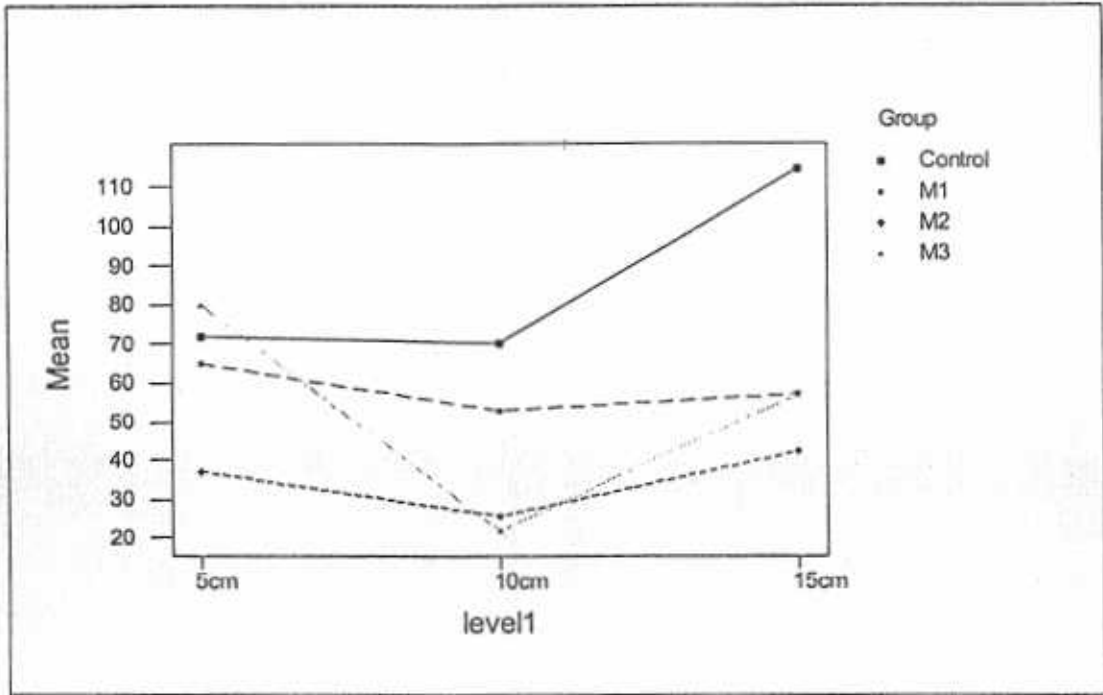


Fig. 10 Interaction plot – data means for dry weight of *Dichanthium annulatum*

The significant interaction is indicated by the lack of parallelism of the lines in Fig.10. Graph shows that the mean dry weight of *Dichanthium annulatum* plant is high at cutting and salinity level 15cm with no cutting (Control). So the dry weight of *Dichanthium annulatum* at 15cm cutting level with no duration increased than other interactions.

Table 27. ANOVA results for the study of growth in dry weight of *Panicum antidotale*.

General Linear Model: Weight versus Group, Level						
Factor	Type	Levels	Values			
Group	fixed	4	Control	M1	M2	M3
Level	fixed	3	10cm	15cm	5cm	
Analysis of Variance for Weight, using Adjusted SS for Tests						
Source	DF	Seq SS	Adj SS	Adj MS	F	P
Group	3	122551	122551	40850	691.89	0.000
Level	2	55	55	27	0.46	0.631
Group*Level	6	668	668	111	1.89	0.103
Error	48	2834	2834	59		
Total	59	126108				

Term	Coef	SE Coef	T	P
Constant	56.6500	0.9920	57.11	0.000
Group				
Control	76.283	1.718	44.40	0.000
M1	-9.983	1.718	-5.81	0.000
M2	-38.317	1.718	-22.30	0.000
Level				
10cm	0.750	1.403	0.53	0.595
15cm	0.600	1.403	0.43	0.671
Group*Level				
Control 10cm	5.117	2.430	2.11	0.040
Control 15cm	-6.533	2.430	-2.69	0.010
M1 10cm	-4.417	2.430	-1.82	0.075
M1 15cm	5.733	2.430	2.36	0.022
M2 10cm	-0.083	2.430	-0.03	0.973
M2 15cm	-1.133	2.430	-0.47	0.643

Least Squares Means for Weight

Group	Mean	SE Mean
Control	132.93	1.984
M1	46.67	1.984
M2	18.33	1.984
M3	28.67	1.984

Level			
10cm		57.40	1.718
15cm		57.25	1.718
5cm		55.30	1.718
Group*Level			
Control	10cm	138.80	3.436
Control	15cm	127.00	3.436
Control	5cm	133.00	3.436
M1	10cm	43.00	3.436
M1	15cm	53.00	3.436
M1	5cm	44.00	3.436
M2	10cm	19.00	3.436
M2	15cm	17.80	3.436
M2	5cm	18.20	3.436
M3	10cm	28.80	3.436
M3	15cm	31.20	3.436
M3	5cm	26.00	3.436

In the ANOVA table showed that there is an insignificant interaction between Groups and Levels. Thus there is no interaction effect of Groups and Levels on *Panicum antidotale* plant meaning that the effect of group and level is independent. Furthermore, $P=0.631$ ($P>0.001$) of Levels showed that there is an insignificant difference between Levels (5cm, 10cm, 15cm) means. So the effect of cutting is insignificant. $P=0.000$ ($P<0.01$) of Groups (Control, M₁, M₂, M₃), however, shows that there is significant difference between means. So cutting the *Panicum antidotale* plant after one, two, three months and control is significant. However the mean dry weight of *Panicum antidotale* plant at control Group is 132.93, which is higher than the cutting of one, two and three month (M₁, M₂ and M₃).

For further elaboration the results are shown in Fig.11.

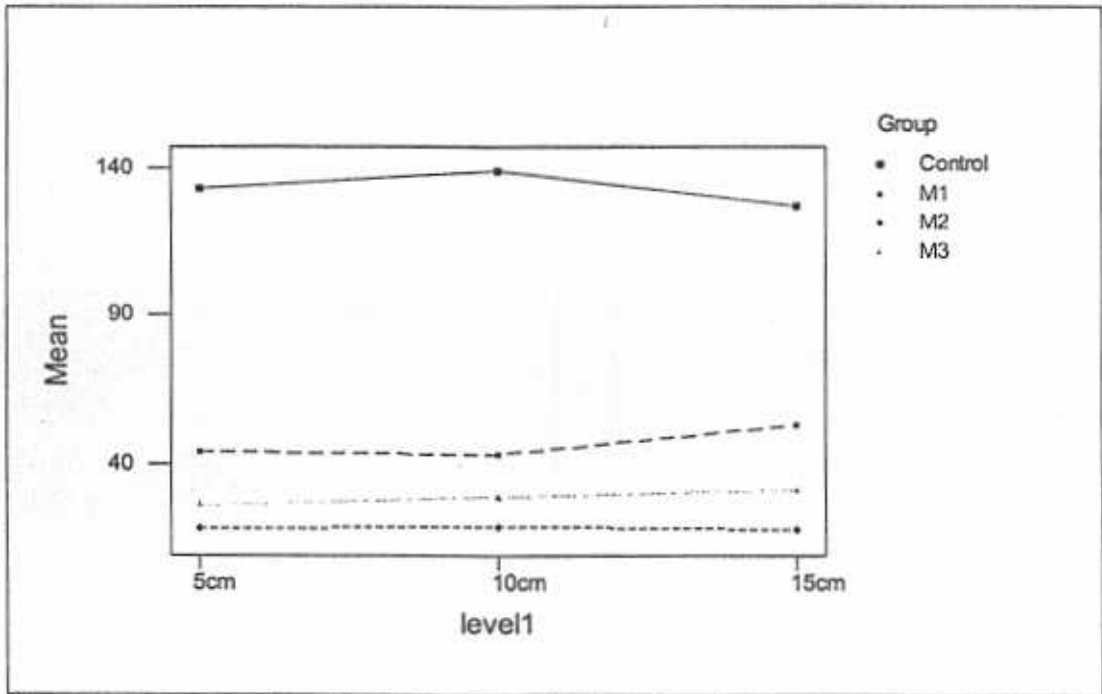


Fig. 11 Interaction plot – data means for dry weight of *Panicum antidotale*

The Fig.11 shows that the interaction is insignificant, which means that the effect of Groups and Levels on *Panicum antidotale* plant dry weight is independent. The need of Main effects plot of Groups and Levels separately is shown in Fig.12.

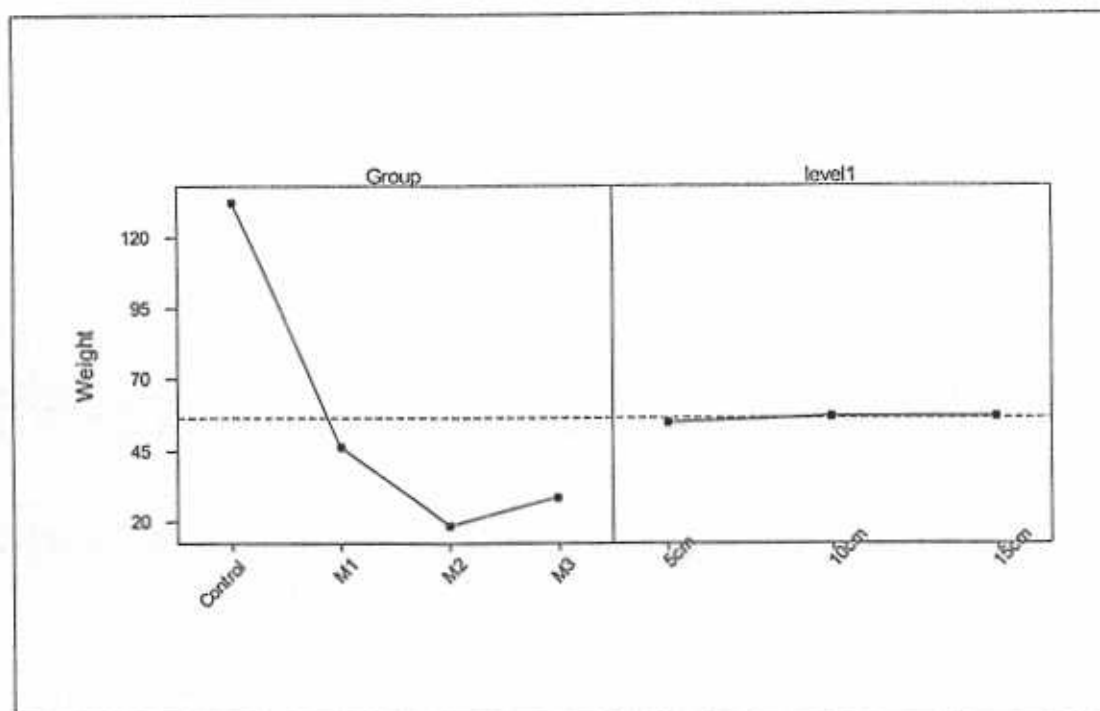


Fig. 12 Main effects plot – data means for dry weight of *Panicum antidotale*

Fig.12 independently shows the main effect of Groups and levels. It is clear that the mean dry weight at different levels is insignificant, which means that they are almost similar at 5cm, 10cm and 15cm cutting levels. The mean weight at different Groups is significant, which shows that mean heights of *Panicum antidotale* plant are different after cutting one month, two months, three months and Control. The dry weight of *Panicum antidotale* plant after no cutting is 132.93, which is higher than the cutting of plant after one, two and three months. These findings are in conformity with Saleem & Call (1992) who after defoliating *Chrysopogon aucheri* and

Cymbopogon jawarnacusa found that *Chrysopogon aucheri* produced more shoot biomass than *Cymbopogon jawarnacusa*.

Table 28. ANOVA results for the study of growth in dry weight of root of *Bothriochloa pertusa*

General Linear Model: Weight versus Group, Level						
Factor	Type	Levels	Values			
Group	fixed	4	Control	M1	M2	M3
Level	fixed	3	10cm	15cm	5cm	
Analysis of Variance for Weight, using Adjusted SS for Tests						
Source	DF	Seq SS	Adj SS	Adj MS	F	P
Group	3	2093.78	2093.78	697.93	63.21	0.000
Level	2	13.30	13.30	6.65	0.60	0.552
Group*Level	6	34.57	34.57	5.76	0.52	0.789
Error	48	530.00	530.00	11.04		
Total	59	2671.65				
Term	Coef	SE Coef	T	P		
Constant	16.8500	0.4290	39.28	0.000		
Group						
Control	9.5500	0.7430	12.85	0.000		
M1	-0.9167	0.7430	-1.23	0.223		
M2	-2.0500	0.7430	-2.76	0.008		
Level						
10cm	-0.6500	0.6067	-1.07	0.289		
15cm	0.2000	0.6067	0.33	0.743		
Group*Level						
Control 10cm	0.250	1.051	0.24	0.813		
Control 15cm	-0.400	1.051	-0.38	0.705		
M1 10cm	-1.483	1.051	-1.41	0.165		

M1	15cm	0.867	1.051	0.82	0.414
M2	10cm	1.450	1.051	1.38	0.174
M2	15cm	-0.800	1.051	-0.76	0.450

Least Squares Means for Weight

Group		Mean	SE Mean
Control		26.400	0.8580
M1		15.933	0.8580
M2		14.800	0.8580
M3		10.267	0.8580
Level			
10cm		16.200	0.7430
15cm		17.050	0.7430
5cm		17.300	0.7430
Group*Level			
Control	10cm	26.000	1.4860
Control	15cm	26.200	1.4860
Control	5cm	27.000	1.4860
M1	10cm	13.800	1.4860
M1	15cm	17.000	1.4860
M1	5cm	17.000	1.4860
M2	10cm	15.600	1.4860
M2	15cm	14.200	1.4860
M2	5cm	14.600	1.4860
M3	10cm	9.400	1.4860
M3	15cm	10.800	1.4860
M3	5cm	10.600	1.4860

The ANOVA (Table 28), showed an insignificant interaction between Groups and Levels. Thus there is no interaction effect of Groups and Levels, which means that the effect of group and level is independent. Furthermore, $P=0.552$ ($P>0.001$) of Levels show that there is an insignificant difference between Levels (5cm, 10cm, 15cm) means. Therefore the effect of cutting levels is insignificant. $P=0.000$ ($P<0.01$) showed that

there is significant difference between means of cutting after one, two and three months. In control (without cutting) the mean of dry weight of root were 26.4, which is higher than the other cutting of one two or three months (M_1 M_2 or M_3). In control group plants had prominent source/sink relationship and the photosynthate get accumulated in the storage tissues of aboveground and belowground parts of the plant as carbohydrate reserves. Juvenile tillers are supported by the parental tillers and the carbohydrate reserves are not depleted. So the dry weights of *Bothriochloa pertusa* and *Panicum antidotale* roots in control was higher then the other plant groups (Bardgett *et al.*, 1998).

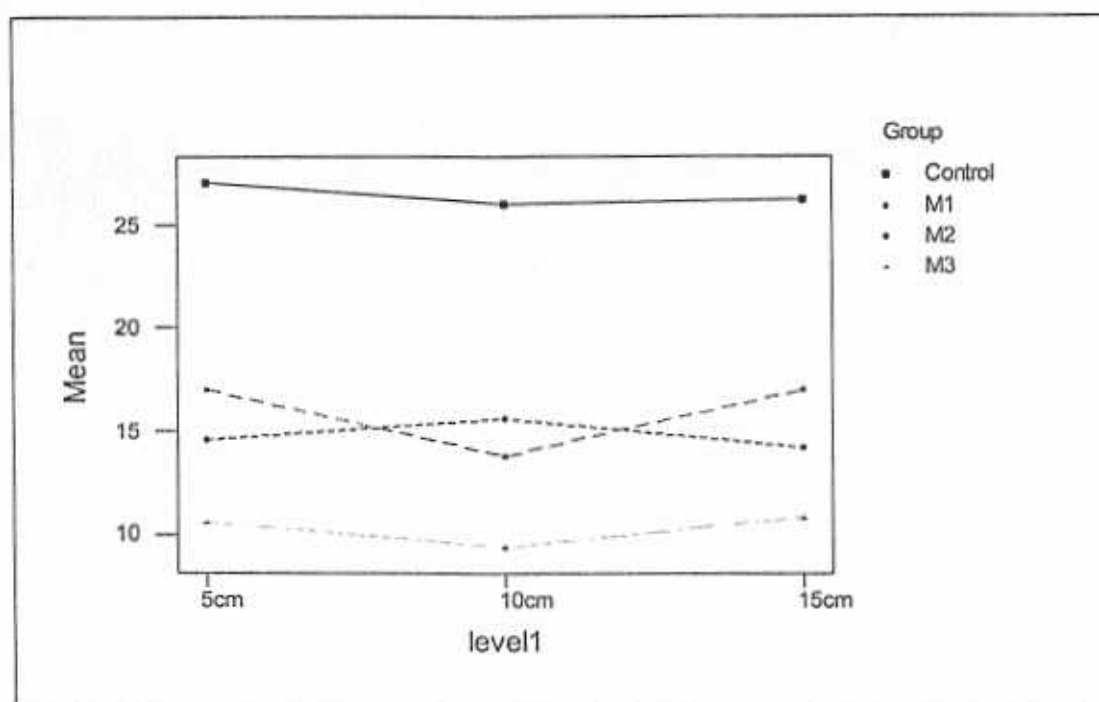


Fig. 13 Interaction plot – data means for dry weight of roots of *Bothriochloa pertusa*

Fig. 13 shows that the interaction effect of Groups and Levels on dry weight of root of *Bothriochloa pertusa* is insignificant and thus independent. Main effect plot of Groups and Levels separately is shown below (Fig.14).

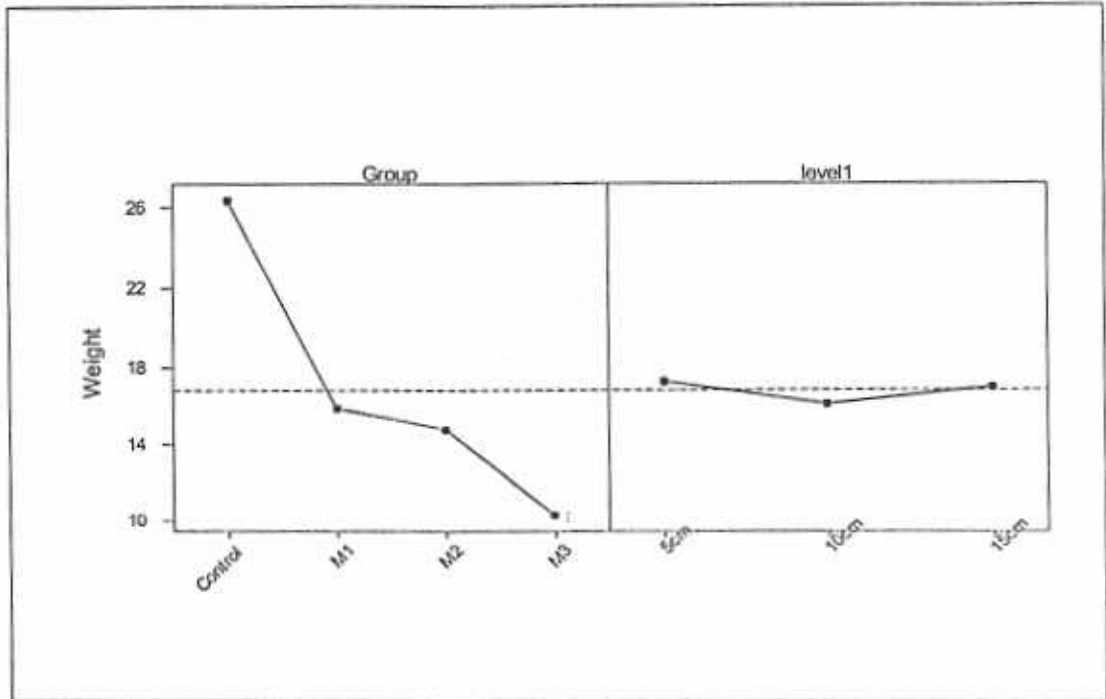


Fig. 14 Main effects plot – data means for weight

Fig.14 showed that the mean dry weight of root at different levels is insignificant, inferring that they have same means at 5cm, 10cm and 15cm cutting levels. And the mean of dry weight of root of *Bothriochloa pertusa* at different Groups is significant, which means that mean weight are different after cutting of one month, two months, three months and Control group. But mean of dry weight of root without cutting (i.e. Control group) is 26.4, which is higher than the cutting of plant after one, two and three months.

Table 29. ANOVA results for the study of growth in dry weight of root of *Dichanthium annulatum*.

General Linear Model: Dry weight versus Group, Level						
Factor	Type	Levels	Values			
Group	fixed	4	Control	M ₁	M ₂	M ₃
Level	fixed	3	10cm	15cm	5cm	
Analysis of Variance for Weight, using Adjusted SS for Tests						
Source	DF	Seq SS	Adj SS	Adj MS	F	P
Group	3	8475.6	8475.6	2825.2	28.19	0.000
Level	2	374.9	374.9	187.5	1.87	0.165
Group*Level	6	21136.0	21136.0	3522.7	35.15	0.000
Error	48	810.4	4810.4	100.2		
Total	59	34796.9				
Term		Coef	SE Coef	T	P	
Constant		53.467	1.292	41.37	0.000	
Group						
Control		20.333	2.238	9.08	0.000	
M1		-5.067	2.238	-2.26	0.028	
M2		-9.800	2.238	-4.38	0.000	
Level						
10cm		-3.467	1.828	-1.90	0.064	
15cm		2.333	1.828	1.28	0.208	
Group*Level						
Control 10cm		-0.333	3.166	-0.11	0.917	
Control 15cm		38.067	3.166	12.02	0.000	
M1 10cm		-6.933	3.166	-2.19	0.033	
M1 15cm		-18.733	3.166	-5.92	0.000	
M2 10cm		4.800	3.166	1.52	0.136	
M2 15cm		-9.000	3.166	-2.84	0.007	

Least Squares Means for Dry weight		
Group	Mean	SE Mean
Control	73.80	2.585
M1	48.40	2.585
M2	43.67	2.585
M3	48.00	2.585
Level		
10cm	50.00	2.238
15cm	55.80	2.238
5cm	54.60	2.238
Group*Level		
Control 10cm	70.00	4.477
Control 15cm	114.20	4.477
Control 5cm	37.20	4.477
M1 10cm	38.00	4.477
M1 15cm	32.00	4.477
M1 5cm	75.20	4.477
M2 10cm	45.00	4.477
M2 15cm	37.00	4.477
M2 5cm	49.00	4.477
M3 10cm	47.00	4.477
M3 15cm	40.00	4.477
M3 5cm	57.00	4.477

Table 29 showed a significant interaction between Groups and Levels. Furthermore, $P < 0.001$ of Groups and Levels, so the main effects of Groups and Levels are also significant. The mean of dry weight of root at Control (Group) and 15cm(Level) is 114, which is higher than other interaction of Groups and Levels. The dry weight of root of *Dichanthium annulatum* plant at 15cm cutting level and without cutting that is Control group is much higher than other cutting levels with different durations. Fig. 15

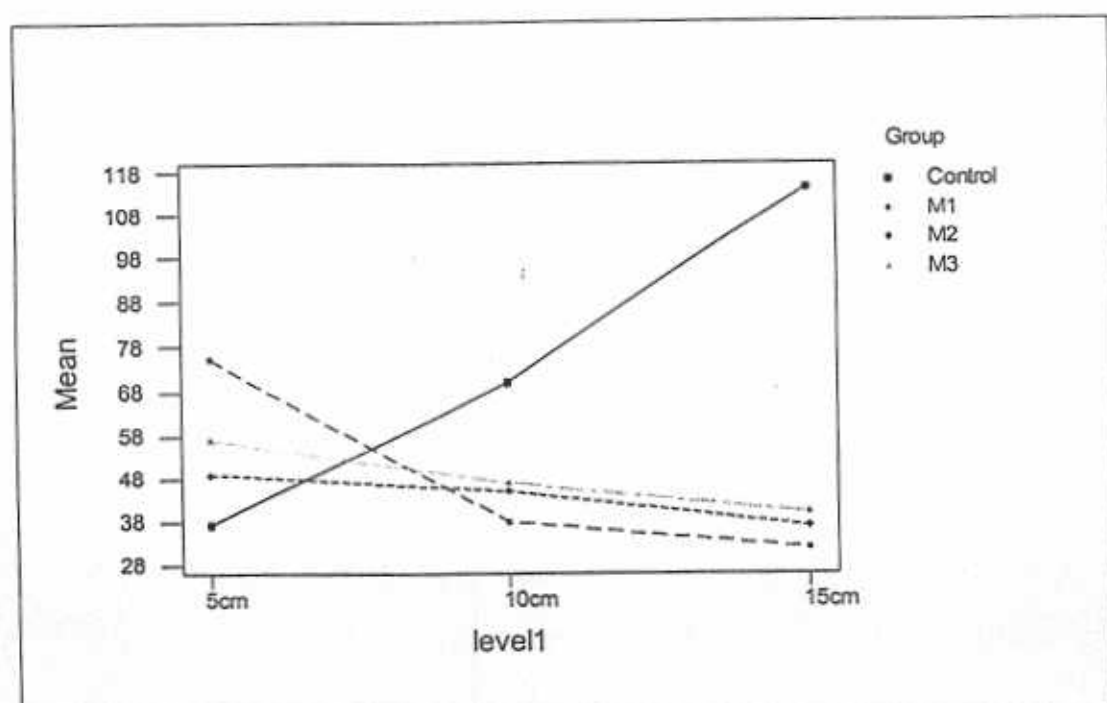


Fig. 15 Interaction plot – data means for weight of *Dichanthium annulatum*

Fig.15 showed that significant interaction is indicated by the lack of parallelism of the lines on interaction Plot. The mean of dry weight of root is higher at 15cm cutting and without cutting. So the dry weight of root of *Dichanthium annulatum* is not affected.

Table 30 ANOVA results for the study of growth in dry weight of root of *Panicum antidotale*.

General Linear Model: Weight versus Group, Level						
Factor	Type	Levels Values				
Group	fixed	4	Control	M ₁	M ₂	M ₃
Level	fixed	3	10cm	15cm	5cm	
Analysis of Variance for Weight, using Adjusted SS for Tests						
Source	DF	Seq SS	Adj SS	Adj MS	F	P
Group	3	412.05	412.05	137.35	5.42	0.003
Level	2	137.03	137.03	68.52	2.70	0.077
Group*Level	6	1849.90	1849.90	308.32	12.17	0.000
Error	48	216.00	216.00	25.33		
Total	59	3614.98				
Term	Coef	SE Coef	T	P		
Constant	30.0167	0.6498	46.19	0.000		
Group						
Control	-3.350	1.125	-2.98	0.005		
M1	1.050	1.125	0.93	0.356		
M2	-1.350	1.125	-1.20	0.236		
Level						
10cm	-1.8167	0.9189	-1.98	0.054		
15cm	-0.0667	0.9189	-0.07	0.942		
Group*Level						
Control 10cm	3.150	1.592	1.98	0.054		
Control 15cm	-1.600	1.592	-1.01	0.320		
M1 10cm	-9.650	1.592	-6.06	0.000		
M1 15cm	1.400	1.592	0.88	0.383		
M2 10cm	9.950	1.592	6.25	0.000		
M2 15cm	-1.400	1.592	-0.88	0.383		

Least Squares Means for Weight

<u>Group</u>		<u>Mean</u>	<u>SE Mean</u>
Control		26.67	1.300
M1		31.07	1.300
M2		28.67	1.300
M3		33.67	1.300
Level			
10cm		28.20	1.125
15cm		29.95	1.125
5cm		31.90	1.125
<u>Group*Level</u>			
Control	10cm	28.00	2.251
Control	15cm	25.00	2.251
Control	5cm	27.00	2.251
M1	10cm	19.60	2.251
M1	15cm	32.40	2.251
M1	5cm	41.20	2.251
M2	10cm	36.80	2.251
M2	15cm	27.20	2.251
M2	5cm	22.00	2.251
M3	10cm	28.40	2.251
M3	15cm	35.20	2.251
M3	5cm	37.40	2.251

The analysis of variance (Table29) shows a significant interaction between Groups and Levels. Furthermore, $P < 0.001$ of Groups and $P > 0.05$ of Levels, indicate that the main effects of Groups are significant but Levels are insignificant. The mean dry weight of root at M_1 (Group) and 5cm(Level) is 41, which is higher than other interaction of Groups and Levels. The dry weight of root at 5cm cutting level with one-month (M_1) duration of cutting is much higher than other cutting levels with different

durations. The results have been further elaborated in the Fig.16 as follows.

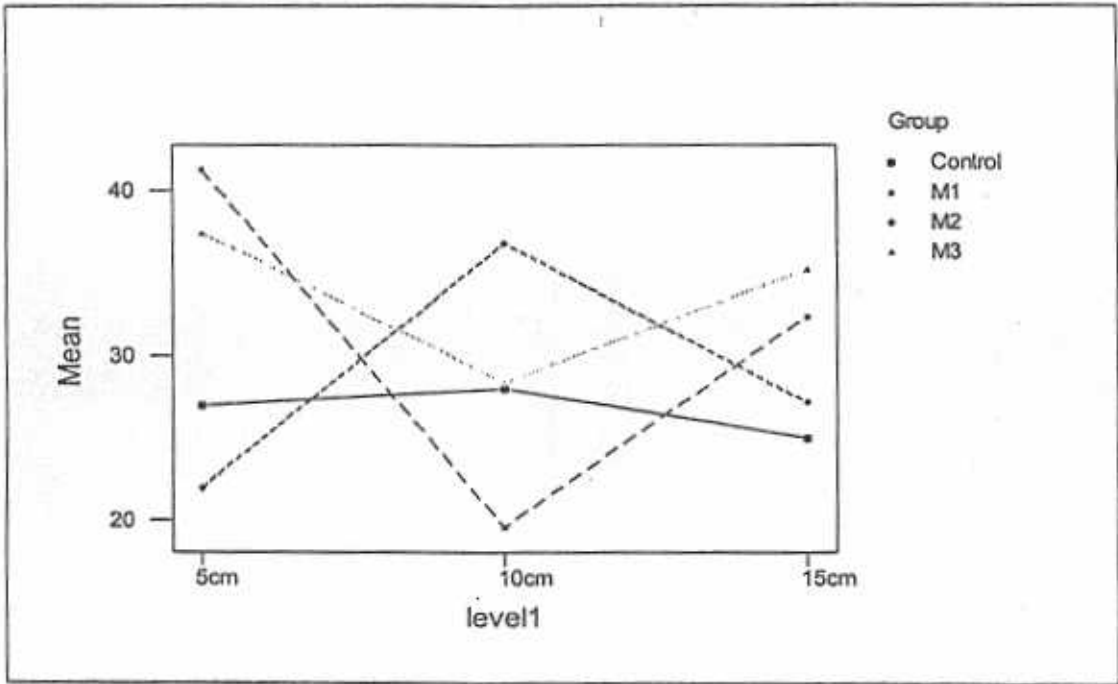


Fig. 16 Interaction plot – data means for dry weight of *Panicum antidotale*

There is significant interaction as indicated by the lack of parallelism of the lines on interaction Plot. Fig. 16 shows that the mean dry weight of root high at 5cm cutting level and the cutting is one month (M_1). The dry weight of root of *Panicum antidotale* at 5cm cutting level with one-month duration increased more than other interactions. When source in a plant is strong the sink in roots is strong thus showing more weight (Bardgett *et al.*, 1998). Saleem & Call (1992) found in their study after defoliation that *Chrysopogon aucheri* produced more root biomass than *Cymbopogon jawarnacusa*. Our findings agree with him.

Table 31. ANOVA results for the study of length of root of *Bothriochloa pertusa*

General Linear Model: length versus Group, Level						
Factor	Type	Levels	Values			
Group	fixed	4	Control	M1	M2	M3
Level	fixed	3	10cm	15cm	5cm	
Analysis of Variance for length, using Adjusted SS for Tests						
Source	DF	Seq SS	Adj SS	Adj MS	F	P
Group	3	92.53	92.53	30.84	0.73	0.540
Level	2	30.53	30.53	15.27	0.36	0.699
Group*Level	6	2020.67	2020.67	336.78	7.95	0.000
Error	48	2033.20	2033.20	42.36		
Total	59	4176.93				
Term		Coef	SE Coef	T	P	
Constant		37.4667	0.8402	44.59	0.000	
Group						
Control		-1.400	1.455	-0.96	0.341	
M1		-0.867	1.455	-0.60	0.554	
M2		0.467	1.455	0.32	0.750	
Level						
10cm		-0.967	1.188	-0.81	0.420	
15cm		0.233	1.188	0.20	0.845	
Group*Level						
Control 10cm		-0.900	2.058	-0.44	0.664	
Control 15cm		-7.300	2.058	-3.55	0.001	
M1 10cm		4.367	2.058	2.12	0.039	
M1 15cm		-6.833	2.058	-3.32	0.002	
M2 10cm		-2.167	2.058	-1.05	0.298	
M2 15cm		3.833	2.058	1.86	0.069	

Least Squares Means for Weight

<u>Group</u>		<u>Mean</u>	<u>SE Mean</u>
Control		36.07	1.680
M1		36.60	1.680
M2		37.93	1.680
M3		39.27	1.680
Level			
10cm		36.50	1.455
15cm		37.70	1.455
5cm		38.20	1.455
Group*Level			
Control	10cm	34.20	2.911
Control	15cm	29.00	2.911
Control	5cm	45.00	2.911
M1	10cm	40.00	2.911
M1	15cm	30.00	2.911
M1	5cm	39.80	2.911
M2	10cm	34.80	2.911
M2	15cm	42.00	2.911
M2	5cm	37.00	2.911
M3	10cm	37.00	2.911
M3	15cm	49.80	2.911
M3	5cm	31.00	2.911

The analysis of variance Table 31 showed that there is a significant interaction between Groups and Levels. Furthermore, it is seen that $P > 0.05$ of Groups and Levels indicate that the main effects of Groups and Levels are insignificant. The mean length of root at M_3 (Group) and 15cm(Level) was 49, which is higher than other interaction of Groups and Levels. The length of root at 15cm cutting level after cutting of three months (M_3) was slightly higher than other cutting levels with different durations.

In M_3-15 the roots were well developed because defoliation level was 15cm high and a considerable portion of photosynthetic tissues were intact. Tri monthly cutting resulted in giving much time to the grass to regenerate its lost parts and develop. Carbohydrate/photosynthate formation was faster. Water potential was high. The roots had to absorb more moisture from the soil. For this purpose the root cells had to divide in order to increase the length of the root. The meristematic tissues got divided at the expense of the food and energy from the above ground part of the grass. So the length of *Bothriochloa pertusa* root at M_3-15 was more as compared to other interactions.

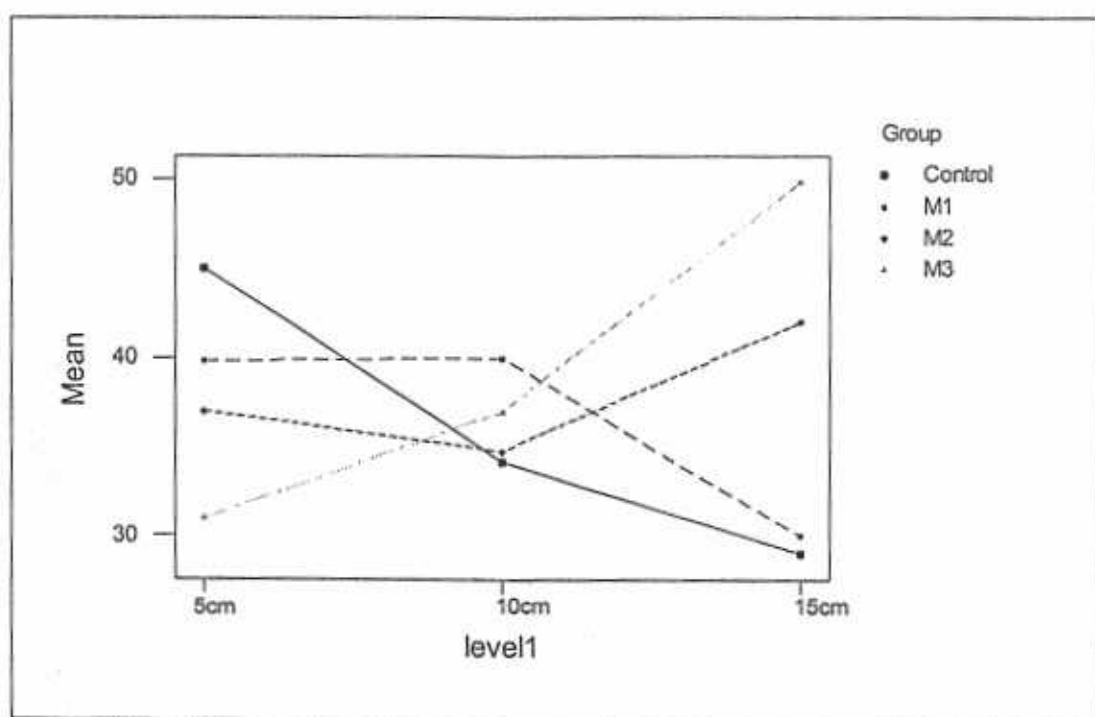


Fig. 17 Interaction plot – data means for root length

Fig. 17 shows significant interaction due to lack of parallelism of the lines on interaction Plot. The mean length of root was more at 15cm cutting level at cutting after three months (M₃). This is in conformity with the findings of Marcum (1999) who found that relative root length in grasses increased under saline condition as compared to control but the findings of Thornton and Millard (1996) who worked on faster growing species *Lolium perenne* and slower grower *Festuca* species, which differed in relation to the rate of increase in root length at different cutting intensities are not in line with our findings.

In *Panicum antidotale* with increasing the height of clipping level there was an increase in the root lengths. The findings of Arredondo & Johnson (1998) who evaluated the influence of clipping on root length of three range grasses clipped twice at 3 intensities of defoliation the root length decreased in two grasses through time; while another grass i.e cheatgrass did not exhibit changes in specific root length through time and also the effects of various levels of NaCl salinization on root length were different. The findings of Zaheer *et al.* (1994) who while working on some forage legumes found that salinity had retarding effect root length are in contradiction with our findings.

Table 32. ANOVA results for the study of growth in length of root of *Dichanthium annulatum*

General Linear Model: length versus Group, Level						
Factor	Type	Levels	Values			
Group	fixed	4	Control	M1	M2	M3
Level	fixed	3	10cm	15cm	5cm	
Analysis of Variance for Weight, using Adjusted SS for Tests						
Source	DF	Seq SS	Adj SS	Adj MS	F	P
Group	3	224.32	224.32	74.77	.33	.276
Level	2	3844.03	3844.03	1922.02	34.15	0.000
Group*Level	6	278.63	278.63	46.44	0.83	0.556
Error	48	2701.20	2701.20	56.28		
Total	59	7048.18				
Term		Coef	SE Coef	T	P	
Constant		42.3833	0.9685	43.76	0.000	
Group						
Control		2.217	1.677	1.32	0.193	
M1		-2.117	1.677	-1.26	0.213	
M2		-1.717	1.677	-1.02	0.311	
Level						
10cm		-5.433	1.370	-3.97	0.000	
15cm		11.317	1.370	8.26	0.000	
Group*Level						
Control 10cm		0.833	2.372	0.35	0.727	
Control 15cm		1.883	2.372	0.79	0.431	
M1 10cm		3.167	2.372	1.33	0.188	
M1 15cm		-3.783	2.372	-1.59	0.117	
M2 10cm		-3.433	2.372	-1.45	0.154	
M2 15cm		2.217	2.372	0.93	0.355	

Least Squares Means for Weight		
Group	Mean	SE Mean
Control	44.60	1.937
M1	40.27	1.937
M2	40.67	1.937
M3	44.00	1.937
Level		
10cm	36.95	1.677
15cm	53.70	1.677
5cm	36.50	1.677
Group*Level		
Control 10cm	40.00	3.355
Control 15cm	57.80	3.355
Control 5cm	36.00	3.355
M1 10cm	38.00	3.355
M1 15cm	47.80	3.355
M1 5cm	35.00	3.355
M2 10cm	31.80	3.355
M2 15cm	54.20	3.355
M2 5cm	36.00	3.355
M3 10cm	38.00	3.355
M3 15cm	55.00	3.355
M3 5cm	39.00	3.355

Table 32 shows an insignificant interaction between Groups and Levels, which means that the effect of group and level is independent. Furthermore, $P=0.000$ ($P<0.001$) of Levels shows significant difference between Levels (5cm, 10cm, 15cm) mean. So the effect of cutting levels is significant at 1% level of significance. The $P=0.276$ ($P<0.01$) of Groups (Control, M_1 , M_2 , M_3) shows insignificant difference between means while cutting after one, two and three months were significant. The means of root length after cutting of three month (M_3) was 53, which was higher than the cutting of one or two months (M_1 or M_2).

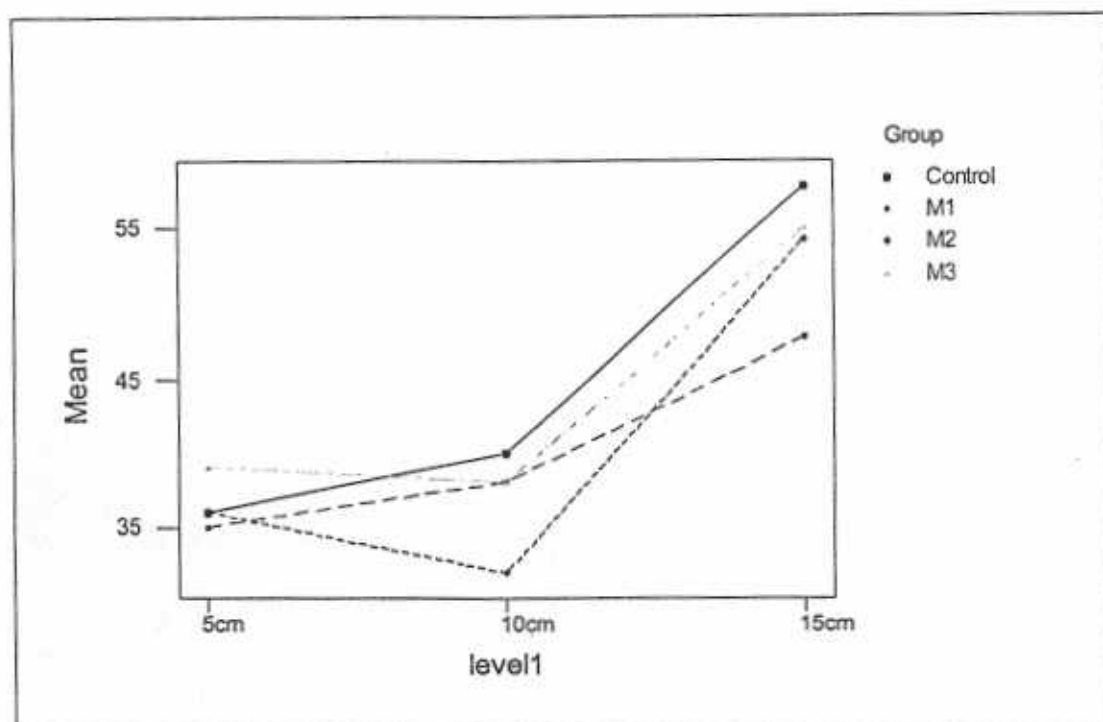


Fig. 18 Interaction plot – Data means for root length of *Dichanthium annulatum*

The lack of parallelism of the lines on interaction plot shows the insignificant interaction. This means that the effect of Groups and Levels on the root length is independent. So we construct Main effect plot of Groups and Levels separately as shown in Fig.19 below:

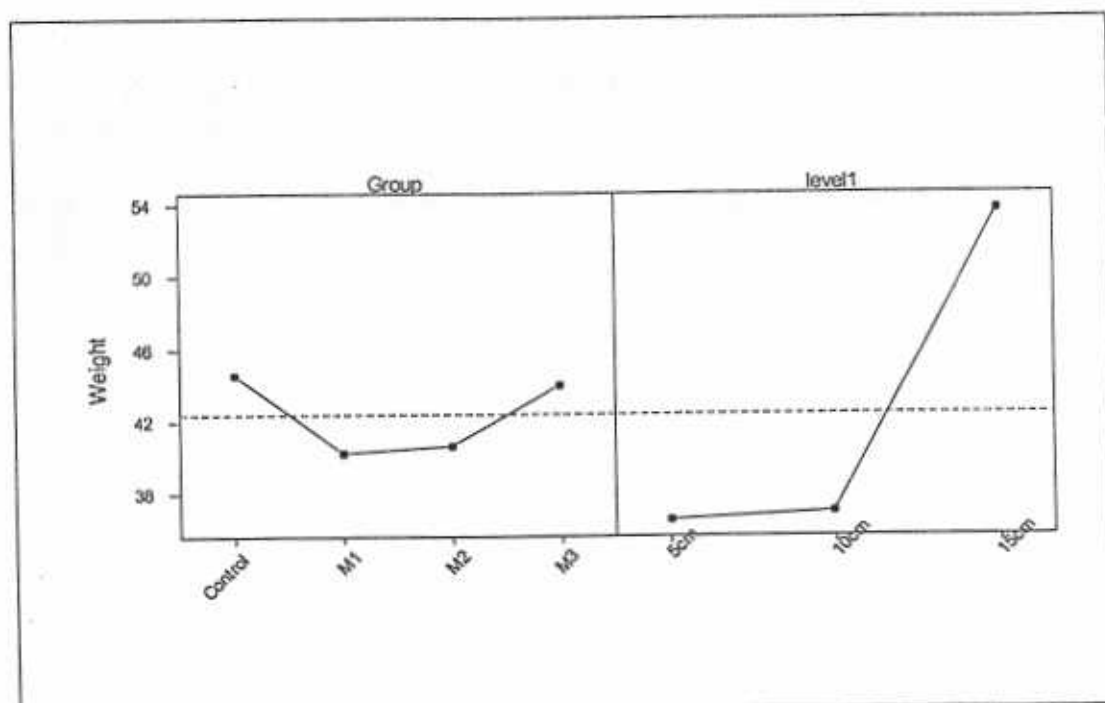


Fig. 19 Main Effects Plot Data means for root length

Fig. 19 shows that the mean root length of *Dichanthium annulatum* plant at different levels (5cm, 10cm and 15cm) were significantly different while the mean length at different Groups is insignificant. However, the mean root length after cutting at 15cm was 53, which was higher than the cutting level of plant at 5cm and 10cm.

Table 33. ANOVA Results for the study of growth in length of roots in *Panicum antidotale*

General Linear Model: length versus Group, Level						
Factor	Type	Levels	Values			
Group	fixed	4	Control M1 M2 M3			
Level	fixed	3	10cm 15cm 5cm			
Analysis of Variance for Weight, using Adjusted SS for Tests						
Source	DF	Seq SS	Adj SS	Adj MS		P
Group	3	1583.07	1583.07	527.69	20.49	0.000
Level	2	2401.43	2401.43	1200.72	46.63	0.000
Group*Level	6	982.43	982.43	163.74	6.36	0.000
Error	48	1236.00	1236.00	25.75		
Total	59	6202.93				
Term		Coef	SE Coef	T		P
Constant		40.5333	0.6551	61.87		0.000
Group						
Control		6.533	1.135	5.76		0.000
M1		0.867	1.135	0.76		0.449
M2		0.467	1.135	0.41		0.683
Level						
10cm		-8.7833	0.9265	-9.48		0.000
15cm		5.8667	0.9265	6.33		0.000
Group*Level						
Control 10cm		-8.083	1.605	-5.04		0.000
Control 15cm		2.067	1.605	1.29		0.204
M1 10cm		4.183	1.605	2.61		0.012
M1 15cm		-1.267	1.605	-0.79		0.434
M2 10cm		5.783	1.605	3.60		0.001
M2 15cm		-1.067	1.605	-0.66		0.509

Least Squares Means for Weight

<u>Group</u>		<u>Mean</u>	<u>SE Mean</u>
Control		47.07	1.310
M1		41.40	1.310
M2		41.00	1.310
M3		32.67	1.310
<u>Level</u>			
10cm		31.75	1.135
15cm		46.40	1.135
5cm		43.45	1.135
<u>Group*Level</u>			
Control	10cm	30.20	2.269
Control	15cm	55.00	2.269
Control	5cm	56.00	2.269
M1	10cm	36.80	2.269
M1	15cm	46.00	2.269
M1	5cm	41.40	2.269
M2	10cm	38.00	2.269
M2	15cm	45.80	2.269
M2	5cm	39.20	2.269
M3	10cm	22.00	2.269
M3	15cm	38.80	2.269
M3	5cm	37.20	2.269

The value of P of interaction Group (Control, M₁, M₂, M₃) and Levels (5cm, 10cm, 15cm) is 0.000 ($P < 0.001$), which is indicator of significance. Furthermore, the main effects of Groups and Levels are also significant ($P < 0.001$). The mean root length at Control (Group) and 5cm (Level) is 56, which is higher than other interactions of Groups and Levels.

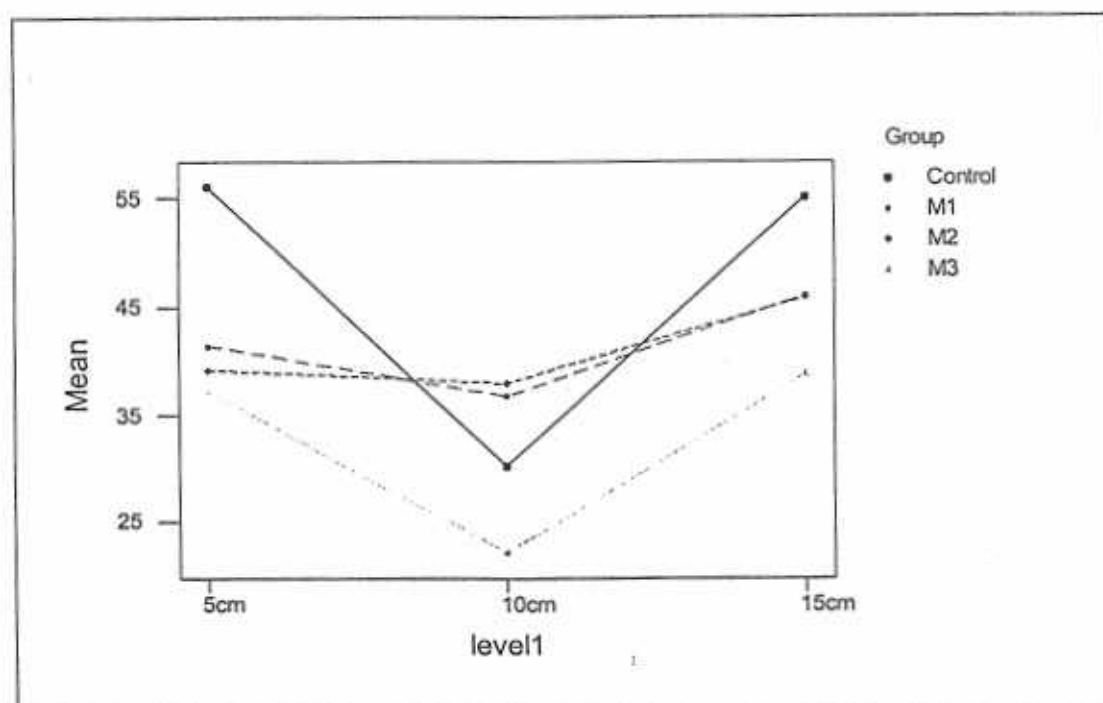


Fig. 20 Interaction – Plot data means of root length of *P. antidotale*

The significant interaction is indicated by the lack of parallelism of the lines on interaction Plot indicates significant interaction Fig. 20 shows the mean root length at 5cm cutting level, which increased than other interactions.

Similar were the findings of Arredondo & Johnson (1998) who evaluated the influence of clipping on root length of 3 range grasses clipped twice at 3 intensities of defoliation. They concluded that root length in Hycrest and Whitmar decreased through time; cheatgrass did not exhibit changes in specific root length through time.

B. Legume *Vicia sativa*

ANOVA results of *Vicia sativa* are presented and discussed in the following paragraphs.

Table 34. ANOVA results for the effects of various levels of NaCl (dSm^{-1}) salinization on average plant survival of *Vicia sativa*. Each value is mean of 5 plants

Descriptives

Average plant survival

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
Control	5	3.4000	.5477	.2449	2.7199	4.0801
5 dS/m	5	4.2000	1.3038	.5831	2.5811	5.8189
10 dS/m	5	4.2000	1.0954	.4899	2.8398	5.5602
15 dS/m	5	4.0000	1.7321	.7746	1.8494	6.1506
Total	20	3.9500	1.1910	.2663	3.3926	4.5074

ANOVA

Average plant survival

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.150	3	.717	.462	.712
Within Groups	24.800	16	1.550		
Total	26.950	19			

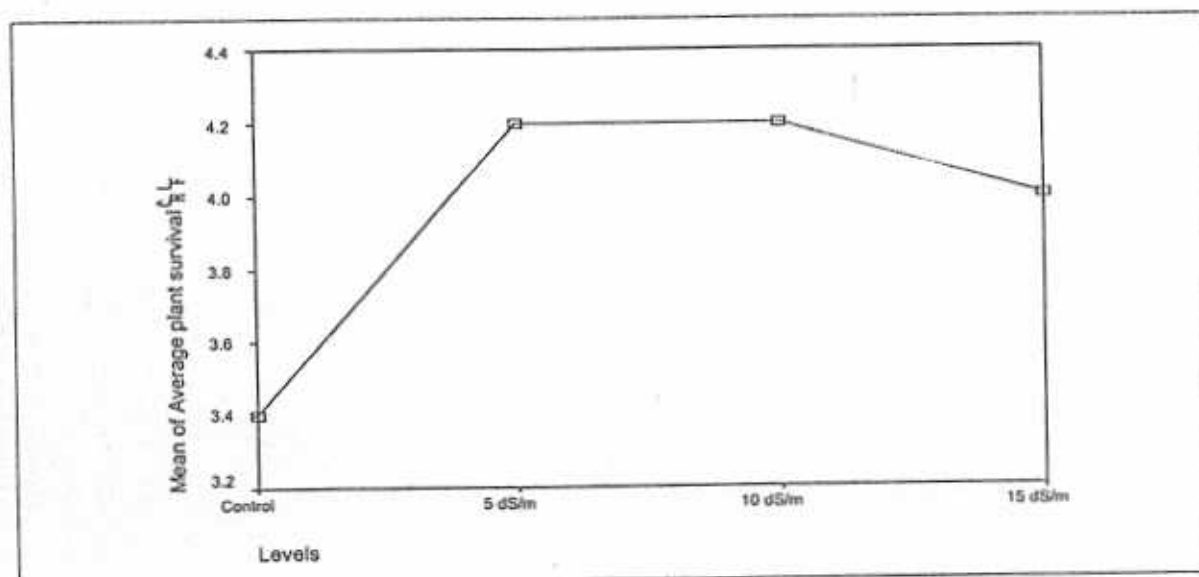


Fig.21. Survival (%) of *Vicia sativa*..

In the analysis of variance (Table34) the value of $P=0.712$ shows that there is an insignificant difference among the different levels of NaCl on average plant survival of *Vicia sativa* at 5% level is of significance. The best level of NaCl based on average criteria is 5dSm^{-1} and 10dSm^{-1} . The mean of NaCl at 5dSm^{-1} and 10dSm^{-1} is 4.2, which is higher than the other levels (Control, 15dSm^{-1}). Graph shows that the mean of average plant survival of *Vicia sativa* is high at salinity level 5dSm^{-1} and 10dSm^{-1} .

Table 35. ANOVA results for the effects of various levels of NaCl (dSm^{-1}) salinization on average number of branches of *Vicia sativa*. Each value is mean of 5 plants

Descriptives

Average No. of tillares

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
Control	5	12.0000	3.0822	1.3784	8.1729	15.8271
5 dS/m	5	12.0000	1.7321	.7746	9.8494	14.1506
10 dS/m	5	9.6000	9.7365	4.3543	-2.4895	21.6895
15 dS/m	5	10.0000	9.1378	4.0866	-1.3461	21.3461
Total	20	10.9000	6.4392	1.4398	7.8864	13.9136

ANOVA

Average No. of tillares

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	24.600	3	8.200	.172	.914
Within Groups	763.200	16	47.700		
Total	787.800	19			

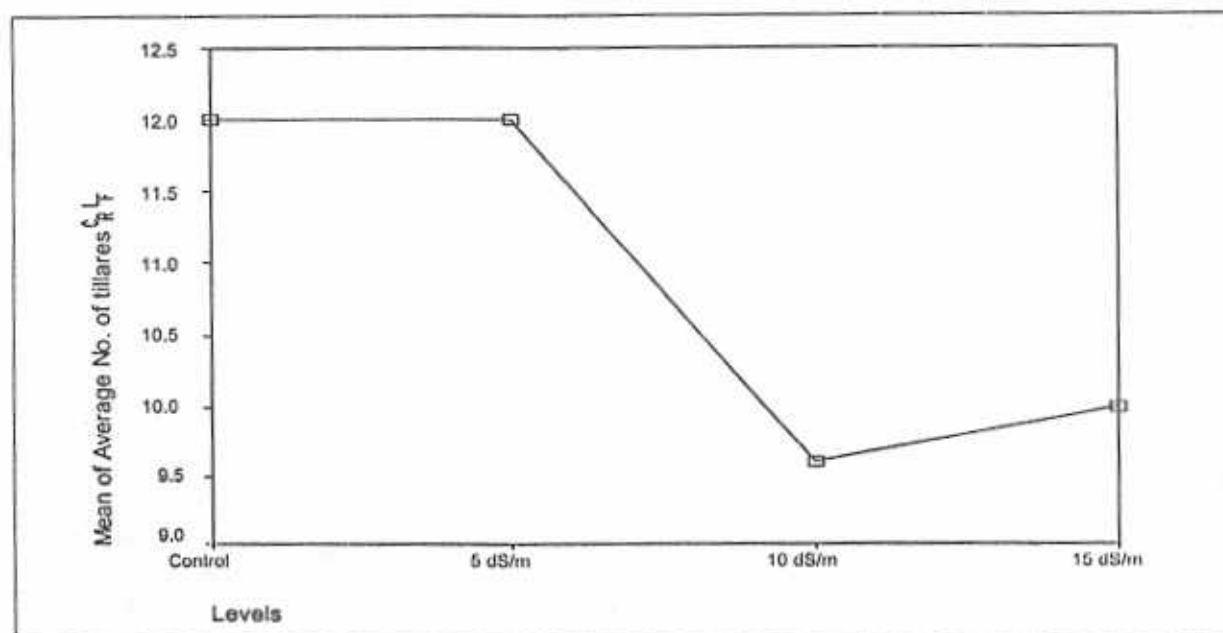


Fig.22. Average number of branches of *Vicia sativa*.

In the Table 35 the value of $P=0.914$ shows that there is an insignificant difference among the different levels of NaCl on branching at 5% level is of significance. The mean of NaCl at 5 dSm^{-1} and Control is 12.00, which is higher than the other levels (10 dSm^{-1} , 15 dSm^{-1}). Fig. 22 shows that the mean of average number of branches of *Vicia sativa* is high at salinity level 5 dSm^{-1} and Control.

Table 36. ANOVA results for the effects of various levels of NaCl (dSm^{-1}) salinization on average length of *Vicia sativa*. Each value is mean of 5 plants.

Descriptives

average length

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
Control	5	25.9000	2.7928	1.2490	22.4322	29.3678
5 dS/m	5	32.6000	4.8270	2.1587	26.6065	38.5935
10 dS/m	5	23.4000	4.0373	1.8055	18.3870	28.4130
15 dS/m	5	26.6000	9.4499	4.2261	14.8664	38.3336
Total	20	27.1250	6.3864	1.4280	24.1361	30.1139

ANOVA

average length

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	228.138	3	76.046	2.225	.125
Within Groups	546.800	16	34.175		
Total	774.938	19			

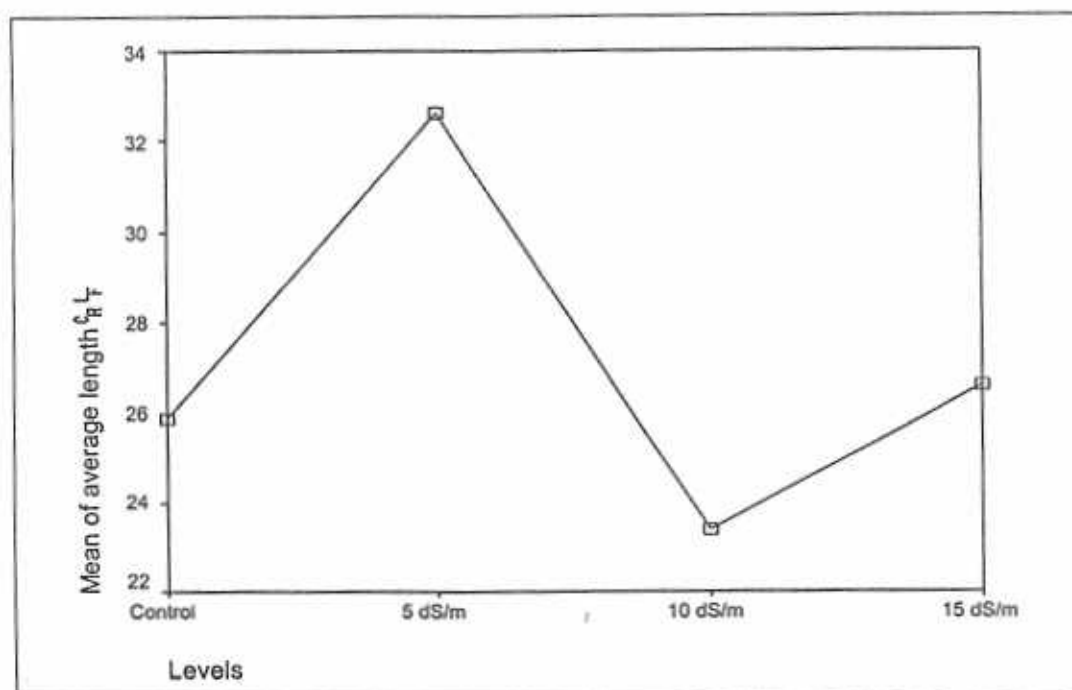


Fig 23. Average length of *Vicia sativa*.

In the analysis of variance Table the value of $P=0.125$ indicates insignificant differences among the different levels of NaCl on length of *Vicia sativa* at 5% level is of significance. Further, the best level of NaCl based on average criteria is 5dSm^{-1} . The mean of NaCl at 5dSm^{-1} is 32.60, which is higher than the other levels (Control, 10dSm^{-1} , 15dSm^{-1}). Fig.23 shows that the mean of average length of *Vicia sativa* is high at 5dSm^{-1} salinity levels.

It is clear from the table that *Vicia sativa* is tolerant to low salinity showing greater average length of the plant as compared to plants grown in higher salinity levels. The average fresh and dry weights of the plants are also greater as compared to *Vicia sativa* plants grown under 10dSm^{-1} , 15dSm^{-1} and control conditions.

Table 37. ANOVA results for the effects of various levels of NaCl (dSm^{-1}) salinization on fresh weight of *Vicia sativa*. Each value is mean of 5 plants

Descriptives

Fresh Weight

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
Control	5	10.1800	4.2181	1.8864	4.9426	15.4174
5 dS/m	5	11.9400	.8198	.3666	10.9221	12.9579
10 dS/m	5	10.5200	1.4050	.6284	8.7754	12.2646
15 dS/m	5	8.7900	1.0052	.4496	7.5418	10.0382
Total	20	10.3575	2.4159	.5402	9.2268	11.4882

ANOVA

Fresh Weight

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	25.096	3	8.365	1.560	.238
Within Groups	85.795	16	5.362		
Total	110.891	19			

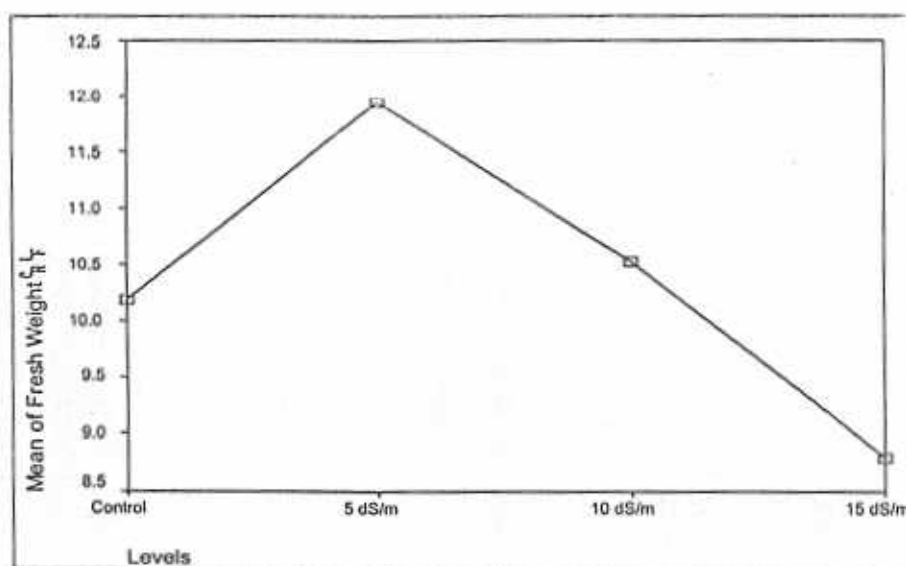


Fig.24. Fresh weight of *Vicia sativa*.

In the analysis of variance (Table 37) the value of $P=0.238$ indicates that there is an insignificant difference among the different levels of NaCl on fresh weight of at 5% level is of significance (Table 37). The best level of NaCl based on average criteria is 5dSm^{-1} 11.94, which is higher than the other levels (Control, 10dSm^{-1} , 15dSm^{-1}). Fig. 24 shows that the mean of fresh weight is high at 5dSm^{-1} salinity levels.

Table 38. ANOVA results for effects of various levels of NaCl (dSm^{-1}) salinization on dry weight of *Vicia sativa*. Each value is mean of 5 plants.

Descriptives

Dry weight

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
Control	5	3.2560	1.2404	.5547	1.7158	4.7962
5 dS/m	5	4.0260	1.4072	.6293	2.2787	5.7733
10 dS/m	5	2.4740	.4019	.1797	1.9750	2.9730
15 dS/m	5	2.7380	.2519	.1127	2.4252	3.0508
Total	20	3.1235	1.0758	.2406	2.6200	3.6270

ANOVA

Dry weight

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	7.013	3	2.338	2.497	.097
Within Groups	14.976	16	.936		
Total	21.989	19			

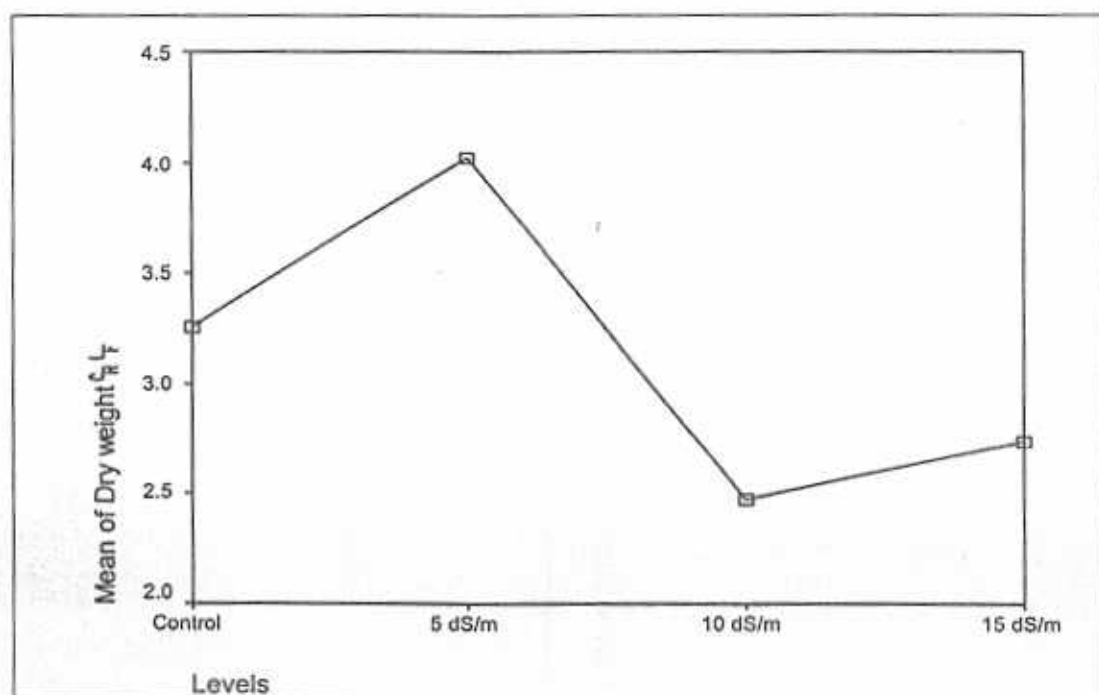


Fig.25. Dry weight of *Vicia sativa*

The value of $P=0.097$ shows a significant difference among the different levels of NaCl on dry weight of at 10% level is of significance (Table 38). . The best mean of NaCl at $5dSm^{-1}$ is 4.02, which is higher than the other levels (Control, $10dSm^{-1}$, $15dSm^{-1}$). Fig. 25 shows that the mean of dry weight of *Vicia sativa* is high at $5dSm^{-1}$ salinity levels

Table 39. ANOVA results for the effects of various levels of NaCl (dSm^{-1}) salinization on length of roots *Vicia sativa*. Each value is mean of 5 plants.

Descriptives

length of roots						
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
Control	5	21.6000	1.8166	.8124	19.3444	23.8556
5 dS/m	5	20.0000	1.8708	.8367	17.6771	22.3229
10 dS/m	5	23.2000	2.7749	1.2410	19.7545	26.6455
15 dS/m	5	35.4000	4.0373	1.8055	30.3870	40.4130
Total	20	25.0500	6.7393	1.5070	21.8959	28.2041

ANOVA

length of roots					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	739.750	3	246.583	32.024	.000
Within Groups	123.200	16	7.700		
Total	862.950	19			

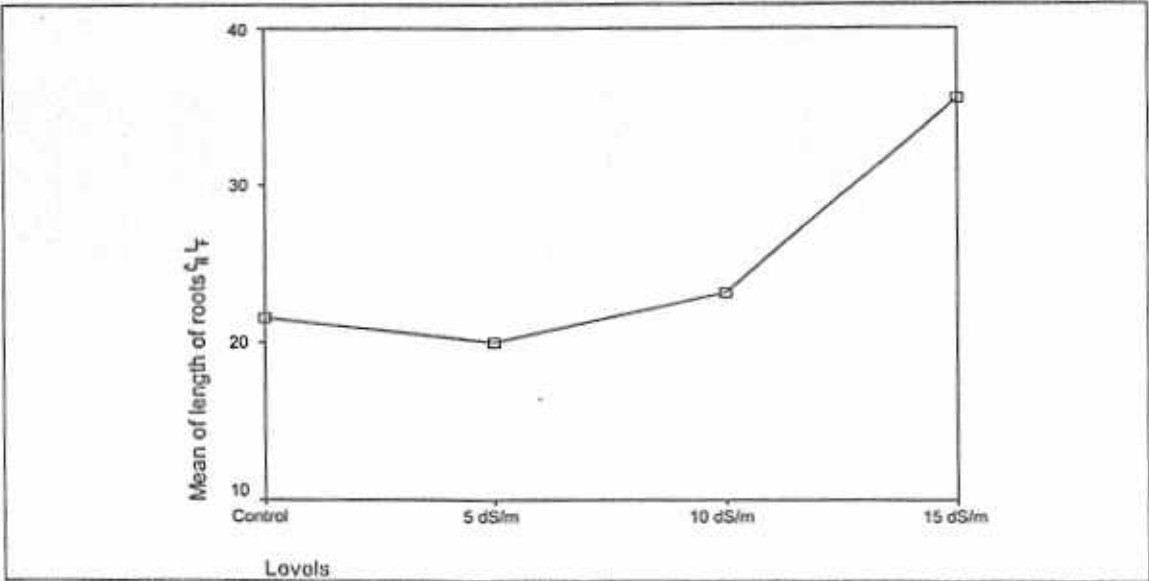


Fig.26. Effect of soil salinization on root length of *Vicia sativa*.

In Table 39 the value of $P=0.000$ indicates that a highly significant difference among the different levels of NaCl on root length at 1% level is of significance. So the effects of various levels of NaCl salinization on root length were different. The mean of NaCl at 15dSm^{-1} is 35.4, which is higher than the other levels (Control, 5dSm^{-1} , 10dSm^{-1}). Fig. 26 shows that the mean of length of roots is high at salinity level 15dSm^{-1} .

Table 40. Effects of various levels of NaCl (dSm^{-1}) salinization on fresh weight of roots of *Vicia sativa*. Each value is the mean of 5 plants.

Descriptives

Fresh Weight of roots

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
Control	5	1.3180	.4402	.1969	.7714	1.8646
5 dS/m	5	.4640	.1274	5.697E-02	.3058	.6222
10 dS/m	5	.4380	.1432	6.406E-02	.2601	.6159
15 dS/m	5	.3000	7.071E-02	3.162E-02	.2122	.3878
Total	20	.6300	.4688	.1048	.4106	.8494

ANOVA

Fresh Weight of roots

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.233	3	1.078	18.301	.000
Within Groups	.942	16	5.889E-02		
Total	4.176	19			

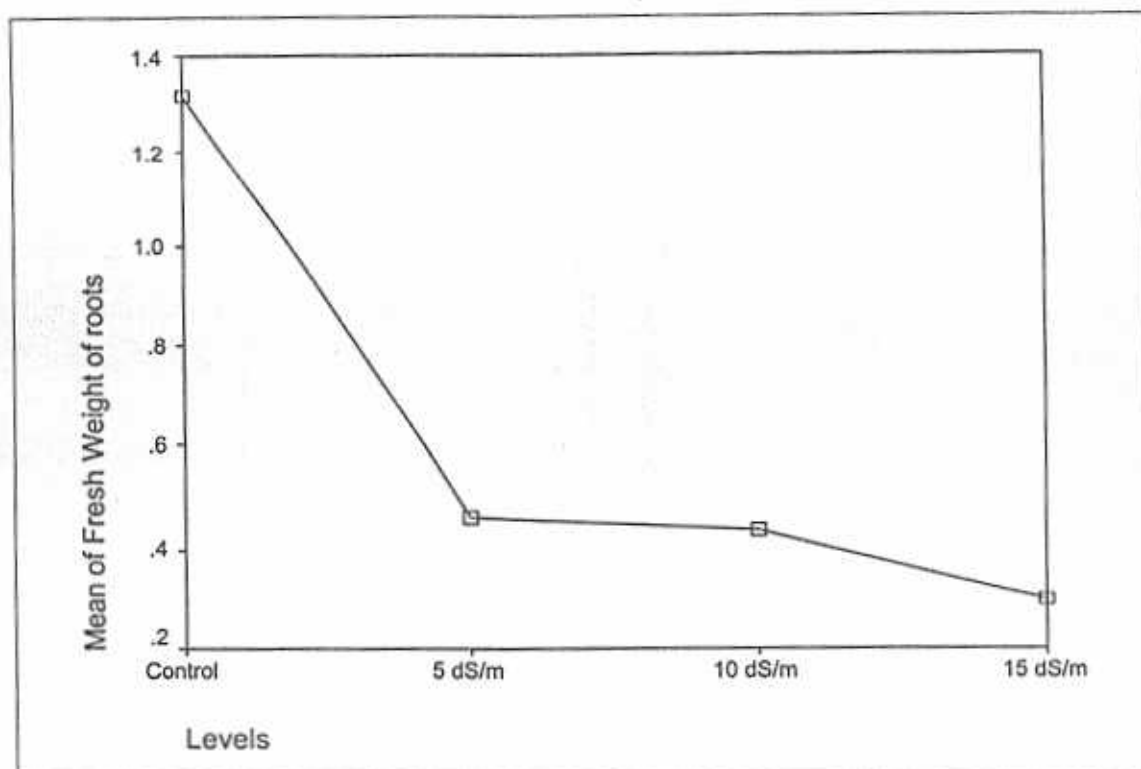


Fig.27. Effect of soil salinization on the fresh weight of roots of *Vicia sativa*.

In the Table the value of $P=0.000$ shows a highly significant difference among the different levels of NaCl on fresh weight at 1% level is of significance. The best level of NaCl based on average is 1.318 , which is higher than the other levels (5dSm^{-1} , 10dSm^{-1} , 15dSm^{-1}). Fig.27 shows that the mean of fresh weight of *Vicia sativa* is high at Control level.

Table 41 Effects of various levels of NaCl (dSm^{-1}) salinization on dry weight of the roots of *Vicia sativa*. Each value is the mean of plants

Descriptives

Dry weight of the roots

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
Control	5	6.800E-02	8.367E-03	3.742E-03	5.761E-02	7.839E-02
5 dS/m	5	5.600E-02	2.408E-02	1.077E-02	2.610E-02	8.590E-02
10 dS/m	5	.1700	6.083E-02	2.720E-02	9.447E-02	.2455
15 dS/m	5	.1340	5.683E-02	2.542E-02	6.343E-02	.2046
Total	20	.1070	6.258E-02	1.399E-02	7.771E-02	.1363

ANOVA

Dry weight of the roots

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4.410E-02	3	1.470E-02	7.757	.002
Within Groups	3.032E-02	16	1.895E-03		
Total	7.442E-02	19			

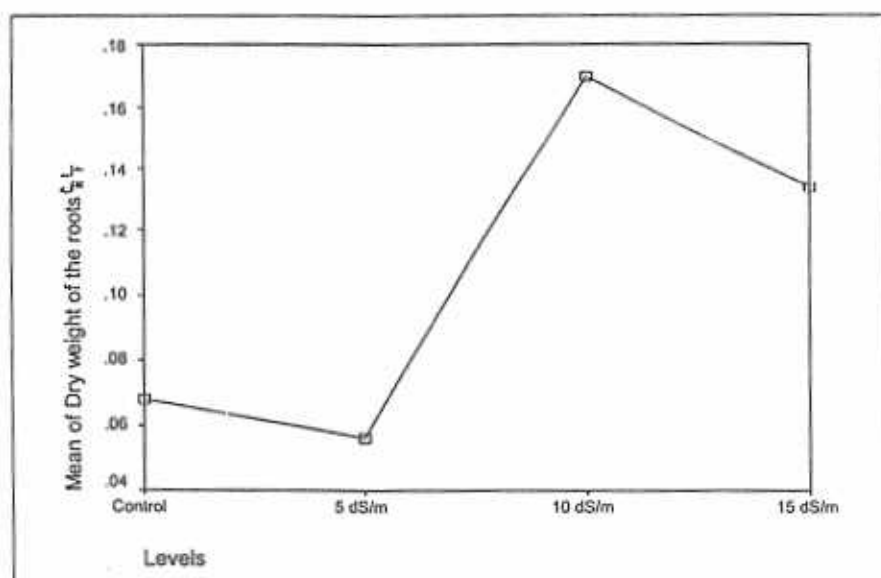


Fig.28. Effect of soil salinization on the dry weight of the roots of *Vicia sativa*.

The analysis of variance showed value of $P=0.02$ indicate that there is a significant difference among the different levels of NaCl on dry weight of the roots at 5% level is of significance (Table 41). The best level of NaCl based on average criteria is 10dSm^{-1} . The mean of NaCl at 10dSm^{-1} is 0.17, which is higher than the other levels (Control, 5dSm^{-1} , 15dSm^{-1}). Fig. 28 shows that the mean of dry weight of the roots of *Vicia sativa* is high at 10dSm^{-1} salinity levels.

CHEMICAL EVALUATION OF SALT TREATED PLANTS

The results of chemical analysis in respect of the three grasses are presented in the following pages.

1. Effects on mineral composition

High concentration of salts badly effects the composition of salt in plants.

Much work has been done on organic constituents of the grasses but little attention has been paid towards their trace metal contents. The present study was also aimed to determine concentrations of essential trace metals. Sodium and potassium are easily uptaken by plants and their high concentration in the saline soils decreases the up take of Ca^{++} and Mg^{++} ions. So all the four basic cations i.e. Ca^{++} , Mg^{++} , Na^+ & K^+ were chosen. Zn, Cu, Fe & Mn were therefore selected for analysis. They are important for regulating structure of essential compounds involved in enzymatic reactions, in osmotic phenomena and transient structural roles.

The results were partly better as compared to control as these plants may have adaptation to grow under saline conditions. Moreover tolerance mechanism facilitates growth while avoidance mechanism reduces the probability and severity of plant defoliation/salinity while grazing/salinity resistance is the relative ability of plants to survive grazing under saline conditions. It is observed that there was a combination of the components i.e. Resistance and Tolerance.

a. Effects on *Bothriochloa pertusa*

Table 42 indicates mineral composition in various treatments in *Bothriochloa pertusa*. The contents of Zn decreased as compared to the control group. Its highest level in treated plants was in at M₁-10. The Cu content did not change. Mn decreased with the treatments. Its highest level was at M₂-5 among treated plants. Fe also decreased. Its highest level was at M₁-10. The Na has obviously increased. The level of K also increased almost double and almost three times at M₁-5 and M₁-10. Ca and Mg have decreased but not that much as compared to others. These findings are in conformity with the findings of Singh & Pandit (1982) who stated that mature, harvested herbage mainly comprising *Bothriochloa pertusa* (24.5%) had positive balances of nitrogen and phosphorus but balance of calcium was negative. These findings are also in conformity with the findings of Rizwan *et al.* (1994) who tested *Sorghum bicolor* for salt tolerance and composition of cell sap for Na, K, Ca and Cl using different salinity levels of control, EC 5, 10, 15 and 20 dS m⁻¹. With increase in salinity K and Ca decreased significantly.

b. Effects on *Dichanthium annulatum*

Data in Table 43 indicates mineral composition of *Dichanthium annulatum* after various treatments. The contents of Zn increased in M₃-10 as compared to the control group and all other groups. The Cu has highest level in M₁-5. Mn increased with the increasing levels of salinity treatments. Its highest level is at M₁-15. Fe

contents decreased to a great extent. Its highest level is at control. The Na has obviously increased. The level of K also increased to almost double. Ca increased in all other groups as compared to the control group but decreased in M₃-5 and M₃-15. Mg increased as compared to the control groups but not that much. Ash content increased as compared to the control group in all the other groups but decreased in M₃-15.

These findings are in conformity with the findings of Qian *et al.* (2000) who conducted greenhouse studies to determine the Sodium chloride tolerance of zoysiagrass (*Zoysia* spp.). Salinity resulted in decreased K⁺ and increased Na⁺ in shoots of all cultivars. Aumont & Xande (1989) stated that the Ca, P, Mg, K, Na, S, Cu, Mo, Zn, Mn, Se, Co and I contents of *Dichanthium annulatum* and *Bothriochloa pertusa*, varied between the 3 sites due to varying soil pH and P solubility. Ca, Mg, S, Se, Co and I contents tended to be higher in natural grassland. P, Cu, Zn and Se were the elements most often below the nutritional requirements of ruminants. Similarly, Suplick *et al.* (2002) found decreased K⁺ and increased Na⁺ in shoots of all cultivars in salt tolerant turf grass.

c. Effects on *Panicum antidotale*

Data in Table 44 indicate the mineral composition of *Panicum antidotale* after various treatments. The Zn contents were highest in M₂-10 as compared to the control group and all the other groups. The Cu contents were of same level in all the

treatments and control group. Mn increased in some of the treatments. Its highest level is at M₂-10. Fe contents decreased to certain extent as compared to control. Its highest level is at M₁-15. The Na has obviously increased in most of the treatments. Its highest level is at M₂-10. The level of K also increased to almost double and almost three times in certain treatments. Its highest level is at M₁-5. Ca increased in most of the groups as compared to the control group and. Its highest level is at M₂-5 but decreased in M₃-5 and M₃-10. Mg increased in three groups as compared to the control group Its highest level is at M₁-15 but not in others groups in which it decreased. Ash content increased as compared to the control group and. all the other groups but not that much as compared to control.

These findings are in conformity with the results of Kalmbacher & Martin (1981) who reported that defoliation had strong influence on the contents of Phosphorus, Calcium, Magnesium, Manganese, Zinc and Copper of creeping blue stem. Similarly, Kalambacher (1983) reported that Indian grass and wiregrass had 38-54% dry matter, 4-7.8% crude protein, 0.05 to 0.08% Phosphorus, 0.46% Potassium, 0.10 to 0.22% Calcium, 0.06% Magnesium, 34 ppm. Iron 35ppm. Manganese, 2ppm copper and 25ppm. Zinc contents. Similarly, Belyuchenko & Shatalova (1994) claimed that *Panicum antidotale* when grown under saline condition indicated P accumulation whereas K decreased.

Table 42. Mineral composition of shoots of *Bohrichloa pertusa* grass under various levels and intervals of clipping

Treatment	Zn (ppm)	Cu (ppm)	Mn (ppm)	Fe (ppm)	Na (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	Ash %
Control	71	<5ppm	45	164	286	5808	7075	2590	7.21
M ₁ -5	53	<5ppm	21	59	178	15813	5850	2470	8.41
M ₁ -10	64	<5ppm	28	104	403	15178	6510	2450	8.33
M ₁ -15	61	<5ppm	32	70	1263	11925	6950	2270	7.41
M ₂ -5	48	<5ppm	30	77	336	11883	4740	1885	6.76
M ₂ -10	39	<5ppm	19	73	231	11960	4270	1935	5.66
M ₂ -15	41	<5ppm	20	60	160	11316	3079	1500	5.04
M ₃ -5	51	<5ppm	22	84	262	14200	4080	2175	6.06
M ₃ -10	61	<5ppm	29	36	276	13318	4545	2325	8.53
M ₃ -15	40	<5ppm	23	44	144	11145	3550	1765	5.95

M₁-5 = Clipping interval one month and level 5 cm; M₁-10 = Clipping interval one month and level 10 cm; M₁-15 = Clipping interval one month and level 15 cm
 M₂-5 = Clipping interval two months and level 5 cm; M₂-10 = Clipping interval two months and level 10 cm; M₂-15 = Clipping interval two months and level 15 cm
 M₃-5 = Clipping interval three months and level 5 cm; M₃-10 = Clipping interval three months and level 10 cm; M₃-15 = Clipping interval three months and level 15 cm

Table 43. Mineral composition of *Dichanthium annulatum* grass under various levels and intervals of clipping

Treatment	Zn (ppm)	Cu (ppm)	Mn (ppm)	Fe (ppm)	Na (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	Ash %
Control	44	<5ppm	26	105	157	4600	4400	1620	5.04
M ₁ -5	56	14ppm	24	66	265	11463	4950	2225	7.39
M ₁ -10	68	<5ppm	28	41	281	12061	5325	2595	9.88
M ₁ -15	61	<5ppm	39	43	386	14768	4755	2635	8.65
M ₂ -5	57	<5ppm	24	83	160	10640	5095	2150	6.38
M ₂ -10	56	<5ppm	35	52	354	10655	6275	2385	8
M ₂ -15	46	<5ppm	24	48	211	10760	4430	2040	6.02
M ₃ -5	57	<5ppm	23	39	158	10620	4100	1935	5.95
M ₃ -10	39	<5ppm	22	53	201	10530	4160	1865	5.43
M ₃ -15	54	<5ppm	35	52	563	10332	4862	2111	4.76

M₁-5 = Clipping interval one month and level 5 cm;M₂-5 = Clipping interval two months and level 5 cm;M₃-5 = Clipping interval three months and level 5 cm;M₁-10 = Clipping interval one month and level 10 cm;M₂-10 = Clipping interval two months and level 10 cm;M₃-10 = Clipping interval three months and level 10 cm;M₁-15 = Clipping interval one month and level 15 cmM₂-15 = Clipping interval two months and level 15 cmM₃-15 = Clipping interval three months and level 15 cm

Table 44. Mineral composition of *Panicum antidotale* grass under various levels and intervals of clipping

Treatment	Zn (ppm)	Cu (ppm)	Mn (ppm)	Fe (ppm)	Na (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	Ash %
Control	52	<5ppm	23	77	1413	10438	4625	3410	5.83
M ₁ -5	45	<5ppm	18	45	1295	24960	5370	3600	9.71
M ₁ -10	59	<5ppm	24	51	2258	19403	5600	3535	9.8
M ₁ -15	58	<5ppm	34	156	2743	20145	5435	3430	9.73
M ₂ -5	57	<5ppm	30	130	1970	16955	10020	5620	12.3
M ₂ -10	62	<5ppm	32	91	3793	13792	7474	3906	9.26
M ₂ -15	42	<5ppm	21	61	3575	16948	4865	2580	7.62
M ₃ -5	43	<5ppm	18	53	1335	16768	4910	4125	7.92
M ₃ -10	53	<5ppm	15	48	2288	15753	4100	2785	7.48
M ₃ -15	46	<5ppm	20	42	2005	16115	4612	4228	7.59

M₁-5 = Clipping interval one month and level 5 cm;M₂-5 = Clipping interval two months and level 5 cm;M₃-5 = Clipping interval three months and level 5 cm;M₁-10 = Clipping interval one month and level 10 cm;M₂-10 = Clipping interval two months and level 10 cm;M₃-10 = Clipping interval three months and level 10 cm;M₁-15 = Clipping interval one month and level 15 cmM₂-15 = Clipping interval two months and level 15 cmM₃-15 = Clipping interval three months and level 15 cm

Abdullah *et al.* (2001) said that sodium contents in different leaves and floral parts in rice increased significantly under salinity stress. While the potassium content decreased significantly in leaves and floral parts. Total protein concentration increased while starch content was greatly inhibited by 50 mM. NaCl salinity.

II: Proximate Composition (Analysis)

The data in the Table 45 indicates that in *Bothriochloa pertusa* the M₃ -10 treatment/group had greater nitrogen contents while crude protein was greater in M₁-5 plants. Ether extract was found more in M₂ -5 while crude fibres were highest in M₁-10. The M₁ -10 plants had the greatest carbohydrates contents and greatest energy as compared to other plants. M₃ -10 plants had more minerals as compared to all other treatments and groups (level of cutting) of plants.

The data in the Table 46 shows that in *Dichanthium annulatum* nitrogen contents and crude protein was greater in M₁-15 plants as compared to other plants in different treatments and ether extract were highest in M₁ -10. Crude fibres were highest in M₂ -15 plants. The plants of M₁-5 treatment group were found to have the greater mineral contents as compared to all other treatments and groups of plants. The plants of M₂ -5 treatment/ group were found to have the greater energy as compared to other plants. The greatest carbohydrate content was found in M₃ -5 plants. The data in Table 47 reveal that in *Panicum antidotale* the control group had greater nitrogen content, crude protein and ether extract, while crude fibres were highest in

M₁-15 plants. The M₃ - 5 plants were found to have the highest energy as compared to other plants. The greatest carbohydrates contents were found in M₁ 5 plants. The minerals were found high in M₂ - 15 as compared to all other treatments and groups of plants. Misra & Singh (1982) found high level of carbohydrates in *Dichanthium annulatum* as compared to *Polypogon monspeliensis*, and *Echinochloa* under varying clipping regimes. Honkanen *et al.* (1999) stated that defoliation of the main source of photosynthate lowered the concentrations of carbohydrates (fructose and glucose), indicating shortage of carbon. However, whole plant defoliation did not affect the concentrations of leaf carbohydrates.

When comparing data of all the three Tables (Tables 45, 46 & 47) for the %ages of different components, it is clear that *Bothriochloa pertusa* (M₃ -10) plants had more minerals as compared to all other treatments and groups of plants. The M₁-10 plants of *Bothriochloa pertusa* had the greatest carbohydrates contents and greatest energy as compared to all other plants. The M₃ -10 treatment/group of *Bothriochloa pertusa* had greater nitrogen contents while crude protein was greater in M₁ - 5 plants of *Bothriochloa pertusa*. Ether extract was found more in *Bothriochloa pertusa* in M₂ - 5 as compared to all other treatments and groups of all the plant species while crude fibres were highest in M₂ - 15 plants in *Dichanthium annulatum*. Grazing affects the ability of plants to obtain nutrients through photosynthesis. If

some plants are grazed more closely than their neighbours, their ability to compete for resources will be decreased, and those plants may die.

Dichanthium annulatum contained greater %age of moisture content as compared to the other two grasses and more %age of moisture was found in M₁-15 plants of *Dichanthium annulatum* as compared to all other treatments and groups of the other plant species. It is usual to see that NaCl salinity promotes to keep internal balance. It could be one of the reasons that there was more moisture content in *Dichanthium annulatum* grown under salinity 15dsm⁻¹.

Plants in saline habitat retain water to reduce the toxic effects of salts. The physiological adjustment in plants is somewhat similar to that of halophytes. This process inhibits ion toxicity. Accumulation of water; potassium and manufactured organic protein keep the cell sap from dehydrating. Several researchers have demonstrated that Na and Cl ions accumulate in the vacuoles that reduce water contents and cause nutrients imbalance in grasses (Dong *et al.*, 2004).

Similar situation has been observed in the present case. Masood *et al.* (1993) found 5.3% moisture in certain grasses. Kalambacher (1983) reported 38-54% dry matter, 4-7.8% crude protein in Indian grass and wiregrass. Prasad (1993) found higher nutritive value of *D. annulatum*, that is, crude protein, ether extract, nitrogen free extract on grazed grassland compared to protected grassland except crude fibre and ash. Singh & Pandit (1982) harvested mature *Heteropogon contortus* (31.0%) and *Bothriochloa pertusa* (24.5%) and found total digestible nutrients 57.6% crude protein 48.0, ether extract 44.1, crude fibre 64.0, nitrogen-free extract 62.5, total carbohydrate 63.2% and energy was 2.28 Mcal/kg DM.

Table 45. Chemical composition (%age) of *Bothriochloa pertusa* under various levels and intervals of clipping

Treatment	N	Crude protein	Ether extract	Crude fibre	Mineral contents	Carbohydrates	Total Energy
Control	1.023	6.395	1.210	39.120	6.500	38.600	190.870
M1-5	0.253	7.830	1.115	31.980	6.670	44.720	220.235
M1-10	0.869	7.430	1.775	41.990	7.240	83.370	378.015
M1-15	0.784	4.900	2.500	35.135	8.090	41.185	206.840
M2-5	0.844	5.275	2.260	34.450	7.115	42.820	212.720
M2-10	0.875	5.470	1.195	33.620	7.550	44.160	209.275
M2-15	0.742	4.600	2.205	34.500	6.830	43.785	213.525
M3-5	1.058	6.350	1.965	32.350	7.085	42.550	214.525
M3-10	1.889	7.430	1.340	32.355	8.275	42.485	211.720
M3-15	0.8168	6.660	1.920	35.080	7.600	51.990	228.380

M₁ - 5 = Clipping interval one month and level 5 cm;M₂ - 5 = Clipping interval two months and level 5 cm;M₃ - 5 = Clipping interval three months and level 5 cm;M₁ - 10 = Clipping interval one month and level 10 cm;M₂ - 10 = Clipping interval two months and level 10 cm;M₃ - 10 = Clipping interval three months and level 10 cm;M₁ - 15 = Clipping interval one month and level 15 cmM₂ - 15 = Clipping interval two months and level 15 cmM₃ - 15 = Clipping interval three months and level 15 cm

Table 46 Chemical composition (%age) of *Dichanthium annulatum* grass under various levels and intervals of clipping

Treatment	N	Crude protein	Ether extract	Crude fibre	Mineral contents	Carbohydrates	Total energy
Control	0.904	5.650	1.690	42.375	6.980	34.895	177.560
M1-5	0.921	5.755	1.705	43.550	7.935	32.820	169.645
M1-10	0.912	5.700	1.790	42.750	7.625	33.755	173.930
M1-15	0.989	6.180	1.670	43.900	7.175	31.750	166.750
M2-5	0.912	5.700	1.100	39.600	7.045	38.255	185.720
M2-10	0.699	4.370	1.715	42.750	7.075	35.905	176.535
M2-15	0.733	4.580	1.660	44.425	7.500	33.385	166.800
M3-5	0.666	4.160	1.145	40.450	7.175	38.785	182.085
M3-10	0.631	4.945	1.675	43.250	7.500	35.420	172.535
M3-15	0.7328	4.580	1.670	43.300	7.600	34.310	170.590

M₁ - 5 = Clipping interval one month and level 5 cm;
M₂ - 5 = Clipping interval two months and level 5 cm;
M₃ - 5 = Clipping interval three months and level 5 cm;

M₁ - 10 = Clipping interval one month and level 10 cm;
M₂ - 10 = Clipping interval two months and level 10 cm;
M₃ - 10 = Clipping interval three months and level 10 cm;

M₁ - 15 = Clipping interval one month and level 15 cm
M₂ - 15 = Clipping interval two months and level 15 cm
M₃ - 15 = Clipping interval three months and level 15 cm

Table 47. Chemical composition (%age) of *Panicum antidotale* under various levels and intervals of clipping

Treatment	N	Crude protein	Ether extract	Crude fibre	Mineral contents	Carbohydrates	Total energy
Control	1.090	6.810	1.930	43.050	7.200	32.965	176.470
M ₁ -5	0.922	5.765	1.120	39.500	7.010	38.365	186.600
M ₁ -10	0.869	5.430	1.800	42.900	7.365	34.740	176.880
M ₁ -15	0.970	6.065	1.710	44.100	7.570	32.505	169.670
M ₂ -5	1.024	6.400	1.215	40.500	7.085	36.740	183.495
M ₂ -10	0.888	5.550	1.575	42.900	7.200	34.580	174.695
M ₂ -15	0.976	6.400	1.855	43.100	7.890	33.205	173.915
M ₃ -5	1.066	6.400	1.220	39.650	6.800	37.865	188.040
M ₃ -10	0.864	5.400	1.835	43.050	7.160	34.405	175.815
M ₃ -15	0.792	4.950	1.850	44.000	7.415	33.765	171.510

M₁ - 5 = Clipping interval one month and level 5 cm;
M₂ - 5 = Clipping interval two months and level 5 cm;
M₃ - 5 = Clipping interval three months and level 5 cm;

M₁ - 10 = Clipping interval one month and level 10 cm;
M₂ - 10 = Clipping interval two months and level 10 cm;
M₃ - 10 = Clipping interval three months and level 10 cm;

M₁ - 15 = Clipping interval one month and level 15 cm
M₂ - 15 = Clipping interval two months and level 15 cm
M₃ - 15 = Clipping interval three months and level 15 cm

Table 48. Comparative moisture contents (%) of three experimental grasses under various levels and intervals of clipping

Treatment	<i>Bothriochloa pertusa</i>	<i>Dichanthium annulatum</i>	<i>Panicum antidotale</i>
Control	8.370	8.410	8.045
M ₁ -5	7.685	8.235	8.210
M ₁ -10	7.715	8.380	7.865
M ₁ -15	8.190	8.875	8.050
M ₂ -5	8.080	8.300	8.060
M ₂ -10	8.050	8.185	8.195
M ₂ -15	8.045	8.210	8.330
M ₃ -5	8.140	8.285	8.065
M ₃ -10	8.115	8.210	8.130
M ₃ -15	7.825	8.540	8.020

M₁ - 5 = Clipping interval one month and level 5 cm;
M₂ - 5 = Clipping interval two months and level 5 cm;
M₃ - 5 = Clipping interval three months and level 5 cm;

M₁ - 10 = Clipping interval one month and level 10 cm;
M₂ - 10 = Clipping interval two months and level 10 cm;
M₃ - 10 = Clipping interval three months and level 10 cm;

M₁ - 15 = Clipping interval one month and level 15 cm
M₂ - 15 = Clipping interval two months and level 15 cm
M₃ - 15 = Clipping interval three months and level 15 cm

CONCLUSIONS

The duration and frequency of clippings has profound effect on the various parameters of growth (i.e., tillering capacity, height, fresh weights and dry weights) of the grasses studied. These parameters showed better results in certain cases at the cutting level of 10 cm with clipping duration of one month.

The total height of the plants in monthly cutting when summed up was better than the height of the plants when cut after three months. In other words, the total forage that could be produced in the three months through monthly clipping was much more than the cutting after three months. Hence, cutting on monthly basis is recommended.

The cutting level also has an effect on the growth of the plants. The results of 10 cm level when compared with the other two levels studied in the experiment i.e. 5 cm or 15 cm were much better. This may be due to the fact that the buds are not much affected at 10 cm level. At 5 cm level most of the buds may be cut, resulting in the poor growth.

The fresh weight of *Bothriochloa pertusa* at 5 cm cutting level with one-month duration increased more than other interactions. The fresh weight of *Dichanthium annulatum* at 5 cm cutting level with three-month duration increased more than other interactions. While the fresh weight of *Panicum antidotale* at 5 cm cutting level with no cutting (Control) increased than other interactions.

As far as the salinity level is concerned, the 10 dSm^{-1} is friendlier in grasses as compared to other levels, i.e., 5 dSm^{-1} or 15 dSm^{-1} . It was observed 5 dSm^{-1} is not affecting the growth parameters to greater extent while; the 15 dSm^{-1} would be affecting too much. Similarly, the interaction effect of the defoliation and salinity was confirmed. It had positive and negative effects depending upon the levels of the interaction. The results of the research suggest that interaction at 10 cm level of cutting and 10 dSm^{-1} of salinity had better result in terms of the growth of the grass plants.

As far as the root biomass is concerned, the dry weight of *Bothriochloa pertusa* with no cutting duration and salinity (Control) was much higher than other cutting and salinity levels with different durations. The dry weight of root of *Dichanthium annulatum* was not affected. The dry weight of roots of *Panicum antidotale* at cutting and salinity level of 5cm with one-month duration increased more than other interactions.

When comparing data of all the three tables for the %ages of different mineral components, it is clear that *Bothriochloa pertusa* had much more minerals and energy in (M_1-10) plants as compared to control and all the treated plants and also had more nitrogen contents which is an important constituent of protein (M_3-10). Moreover *Bothriochloa pertusa* had more crude protein in (M_1-5) plants and more Ether extract in (M_2-5) plants. Potassium content was more in all the treated plants as

compared to control plants of *Bothriochloa pertusa*. It is concluded that *Bothriochloa pertusa* among grasses and clipping level of 10 cm. are the best in many cases and is recommended for plantation in sutibale saline areas.

In *Dichanthium annulatum* the total fresh weights for 10cm level of cutting was greater than 5 and 15 cm level of cutting. Calcium was more in M₂-10 than control and other *Dichanthium annulatum* plants. The contents of Zn in *Dichanthium annulatum* increased in M₃-10 as compared to the control group and all other groups. In *Dichanthium annulatum* Mg was more in all the treated plants as compared to the control group. Ash content increased in *Dichanthium annulatum* as compared to the control group and in all the other groups but decreased in M₃-15. *Dichanthium annulatum* contained greater %age of moisture content as compared to the other two grasses and more %age of moisture was found in M₁-15 plants of *Dichanthium annulatum* as compared to all other treatments and groups of the other plant species. So on the bases of all these it is concluded that *Dichanthium annulatum* is second to *Bothriochloa pertusa* in its properties/qualities and is suitable for cultivation in suitable saline areas with salinity of up to 10 dSm⁻¹ level.

From the findings of the study on *Vicia sativa*, it is concluded that various levels of salinity affect the plant. At 5 dSm⁻¹ level, salinity did not affect too much the growth because from the graph it is conclude that the average length, fresh weight, the

dry weight, number of branches was higher in *Vicia sativa* at salinity 5 as compared to 10 and 15 dSm⁻¹ but the roots at this salinity level were poorly developed showing effect of salinity. At 15 dSm⁻¹, the findings were totally different in *Vicia sativa*.

The 10 dSm⁻¹ level of salinity was friendly in case of grasses in many cases.

RECOMMENDATIONS

1. On the basis of the findings of the recent study, moderately saline areas can be utilized by growing *Bothriochloa pertusa*, *Dichanthium annulatum* and *Panicum antidotale* etc.
2. Similarly, the cultivation of *Vicia sativa* with these grasses would be more productive because being a leguminous plant it will improve fertility of the grassland.
3. The cutting level of 10 cm and cutting interval of one month would be more appropriate. Wise strategies of grazing management must be coupled with inherent grazing resistance mechanism of the species in a grazed system
4. For the conversion of grazing land into productive rangeland the most important factors to consider are salinity tolerance level of plants, salinity level of the saline area, animal type and forage need according to which the plant species should be chosen.

5. Grazing model should be established to account for pasture size, stocking rates, animal nutrition and forage need.
6. The study may be repeated at places in natural environment under different weather conditions for confirmation of the findings of the present study or otherwise.
7. The research may be repeated at field under controlled conditions.

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