Global Journal of Science Frontier Research
Biological Sciences
Volume 12 Issue 7 Version 1.0 Year 2012
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Altitudinal and Seasonal Effect on Herbaceous Biomass in Tehsil Takht-e-Nasrati, District Karak, Pakistan

By Musharaf Khan & Farrukh Hussain

University of Peshawar, Pakistan

Abstract - To record the existing herbaceous biomass diversity of Tehsil Takht-e-Nasrati, Pakistan, field surveys were regularly conducted in spring, summer and winter 2009-2010. There was an increasing inclination of Biomass as of spring to winter. However, the collective amount of grasses and herbs Biomass (426.5 Kg.hec^{-1}) was significantly higher during spring at Stand 1 as compared to other seasons and Stands. The average grasses and herbs Biomass was decreasing with increasing altitude. The herb Biomass was high (730 Kg.hec^{-1}) during spring at Stand 1 and low during summer (194 Kg.hec^{-1}) at Stand 4. The grass Biomass was high during summer (173 Kg.hec^{-1}) at Stand 3 and less during winter (74 Kg.hec^{-1}) at Stand 1. The total herb mean Biomass was greater during spring (536.30 Kg.hec^{-1}) while the grass had (129.9 Kg.hec^{-1}) during summer. The total average Biomass was high at Stand 1 (262.58 Kg.hec^{-1}). The total mean and average Biomass of Tehsil Takht-e-Nasrati was 223.23 Kg.hec^{-1}. The Biomass of herbs helps to conserve the bio energy, chemical constituents and heat in existing area.

Keywords : herbaceous biomass , seasonal effect, altitudinal effect, Takht-e-Nasrati, pakistan.

GJSFR-C Classification : FOR Code: 070304

Strictly as per the compliance and regulations of :

Altitudinal and Seasonal Effect on Herbaceous Biomass in Tehsil Takht-e-Nasrati, District Karak, Pakistan

Musharaf Khan [α] & Farrukh Hussain [σ]

Abstract - To record the existing herbaceous biomass diversity of Tehsil Takht-e-Nasrati, Pakistan, field surveys were regularly conducted in spring, summer and winter 2009-2010. There was an increasing inclination of Biomass as of spring to winter. However, the collective amount of grasses and herbs Biomass (426.5 Kg.hec^{-1}) was significantly higher during spring at Stand 1 as compared to other seasons and Stands. The average grasses and herbs Biomass was decreasing with increasing altitude. The herb Biomass was high (730 Kg.hec^{-1}) during spring at Stand 1 and low during summer (194 Kg.hec^{-1}) at Stand 4. The grass Biomass was high during summer (173 Kg.hec^{-1}) at Stand 3 and less during winter (74 Kg.hec^{-1}) at Stand 1. The total herb mean Biomass was greater during spring (536.30 Kg.hec^{-1}) while the grass had (129.9 Kg.hec^{-1}) during summer. The total average Biomass was high at Stand 1 (262.58 Kg.hec^{-1}). The total mean and average Biomass of Tehsil Takht-e-Nasrati was 223.23 Kg.hec^{-1}. The Biomass of herbs helps to conserve the bio energy, chemical constituents and heat in existing area. The herbaceous Biomass are also depends on the basis of altitude, seasonal variation, environment factors and soil types.

Keywords : herbaceous biomass, seasonal effect, altitudinal effect, Takht-e-Nasrati, pakistan.

I. Introduction

Herbaceous biomass is the total mass of the herbs and grasses within a given unit of ecological region. In the bio-based wealth, herbaceous biomass such as herbs and perennial grasses will turn out to be important cellulosic supply for conversion to bio fuel, chemical constituents, energy and heat in the modern time. Due to environmental condition and grazing the biomass of plants is vastly changeable (Olson & Richard, 1989). The biomasses of rangeland are turning downed with the overgrazing, over exploitation and soil erosion (Hussain & Durrani, 2007). One of the most important factors controlling survival, production of range plants, germination, abundance and subsequent growth is water availability (Brown, 1977, Pitt & Heady, 1978). In deserts the plants are mostly partial by means of water so an important role exerted on structure and function of many rangeland ecosystems are water availability. (Noy-Meir, 1973) still, a direct correlation between precipitation and plant production is not regularly observed (Charley, 1972, Webb *et al*., 1978). Biomass and production of plants are diminished or demolish through grazing (Facelli & Pickett, 1991). Decomposition process is very low in arid regions due to lack of water that bounds microbial action on the soil surface and plants availability. (Knapp & Seastedt, 1986). Biomass information and judgment methods have been often discussed by Sah et al., 2004. The evaluation of wild land manners prospective necessitates quantitative estimation of accessible weights by condition and by size category (Rothermel, 1972). Herbs and grasses are one of the mass vital fuel types in the region and has no long been associated with frequent forest. Herbs, grasses and shrubs plant communities and open forest are not widespread in Takht-e-Nasrati due to dry condition of the area. Thus, estimation of herbaceous biomass is of essential influence in combustion, forest, grazing and land management in the region. Different study were done on plants biomass in world and in different area of Pakistan such as; Martin et al., (1981), Smith and Gray, (1983), Hussain and Durrani, (2007), Zhou et al., (2007), Ahmad et al., (2009), Saleem, et al., (2009) Moyo, *et al*., (2011). Herbs and grasses are one of the mass vital fuel types in the present region and has no long been linked with normal forest. Therefore, numerous studies on different community's level are required to workout to plan the relationships between vegetation structure and composition. No effort is available especially on the herbaceous biomass as of the present area. The key point of this study was to determine the Biomass of herb and grass species in research area. The results of this study will also show useful in ecology, security, conservation and management of plant species. The objective of this research work was to evaluate the fresh biomass of herbs and grasses on the basis of altitude and seasonal variation in Tehsil Takht-e-Nasrati, District Karak, Pakistan.

II. Methods and Material

a) Research area

The Tehsil Takht-e-Nasrati is situated at 32.47° to 33.28° North and 70.30 ° to 71.30° East. The research area is bounded by Tehsil Karak on the North East, District Mianwali on the East, District Lakki Marwat on the South West and Tribal area Adjoining District Bannu

Author α σ : Department of Botany, University of Peshawar, Pakistan.

on the West. The area was divided into four Stands i.e. Stand 1 (340 -399m), Stand 2 (400 – 499m), Stand 3 (500 – 599m) and Stand 4 (600 – 700m) on the origin of elevation (Fig. 1). The total area of Tehsil is about 613.66 Sq. kilometer. Majority of the area consists of rigged dry hills and rough fields areas i.e. 323.97 Sq. kilometers and agriculture land is about 289.7 Sq. kilometer. The major income source of the people is Agriculture, which is rain depended. The area is situated at 340 m above the sea level.

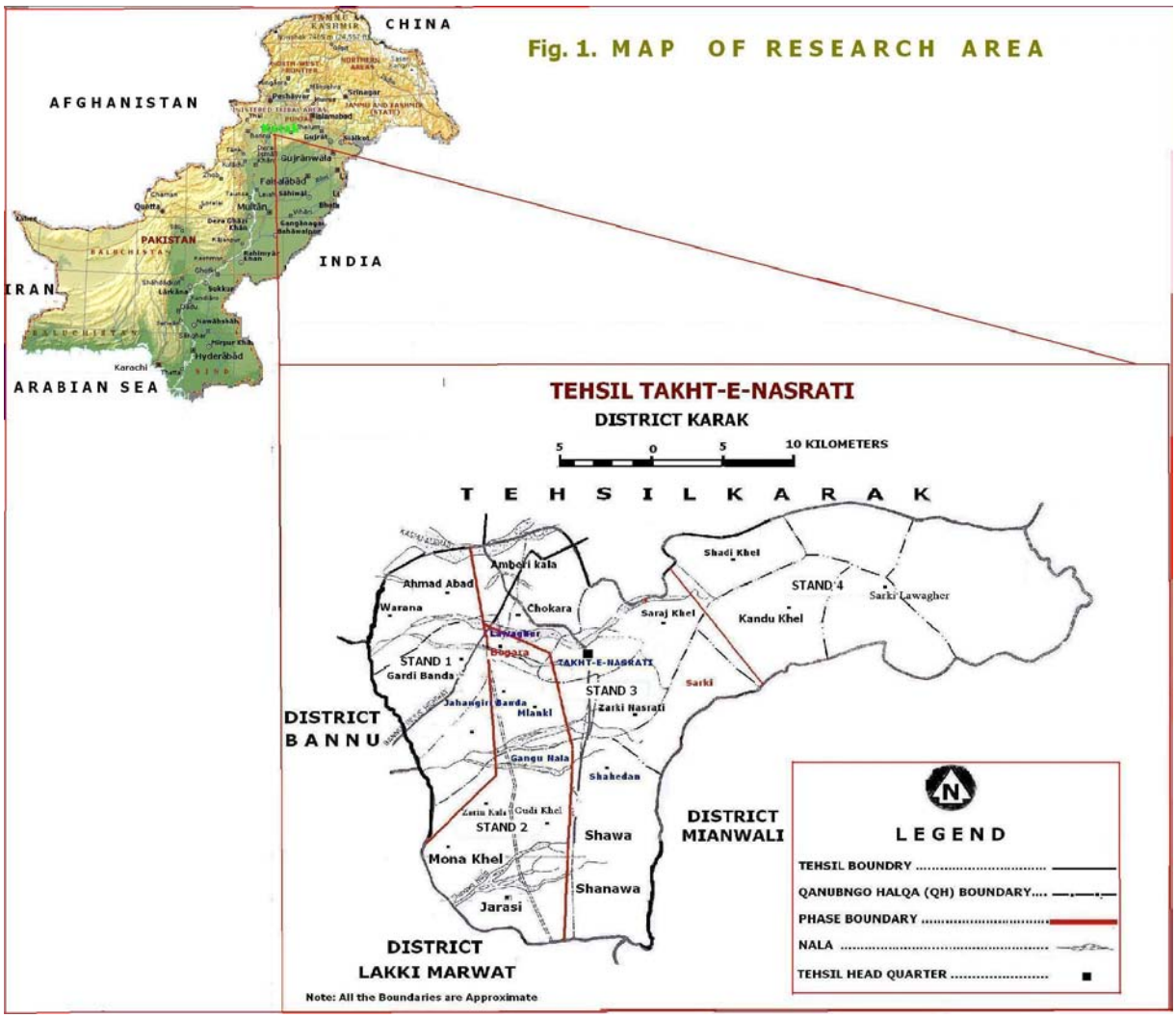


Fig.1 : Map of Tehsil Takht-e- Nasrati showing research spots

The major problem of the area is shortage of drinking water because the rainfall is scanty in the area. In the year 2010, 62.5 mm. y^{-1} of rainfall recorded. The area is very hot in summer and very cold in winter. June and July are the hottest months, where as December and January are the coldest months. In the year 2010 the mean maximum temperature was 39.5 C°, in the month of the May during summer, where as the mean minimum temperature was as low as 4 C ° in the month of January during winter. The wind speed was different in different years. In the year 2009 the wind speed was high 6 Km per hour (h) in the month of July whereas in the year 2010 it was high in the month of April 7.2 Km. h^{-1}. The humidity is between 62 to 86 during summer and lowest in January and February. The soil temperature is high 31.11 C° in July during summer while low 2.1 C° in January during winter (Table 1).

Table 1 : Average climatic data of Tehsil Takht-e-Nasrati, District Karak for the year 2010.

Months	Temperature (C^0)		Humidity (%)		Rainfall (mm)	Soil Temperature (C^o) Average	Wind speed (Km h^{-1})
	Max	Min	Max	Min			
January	20	4	-	-	19.0	2.1	2.1
February	21	7	-	-	19.2	3.5	3.3
March	30	15	82	39	11.5	5.9	2.5
April	35	20	68	32	20.2	10.4	7.2
May	38	23	62	26	1.8	10.6	5.7
June	34	27	64	40	80.5	13.4	5.1
July	34	24	86	44	345.2	31.11	5.2
August	33.7	25.6	84.7	52.6	167	30	3.4
September	34	20	73	36	82.8	28.33	1.95
October	32	19	85	48	-	25	2.23
November	26	10	77	36	-	20.55	2.32
December	21	4	84	38	2.8	14.34	2.61

III. Experimental Protocol

Samples were taken on the basis of altitude and preferred designed for diversity of situation through field surveys, in period of three expected seasons i.e. spring, summer and winter for two years 2009-2010, in order to test whether the season's arrangement inclined estimate biomass of plant species. The relationship of growing season to latitude was developed from available global positioning system (GPS) data. Time and length of the growing season was then estimated for each study site. The area was divided into four Stands and each Stand further divided into more than four sites on the source of herbs availability in the area. In each site 10 quadrats (1x1 m) were chosen during spring, summer and winter for estimation of above ground biomass. Relative abundance of each vegetation species as estimated on a broad. All species present in the area were selected for Biomass study on the source of reference unit, relative abundance of each vegetation species, range of stand, age-classes, geographic locations and edaphic conditions. Particular plant specie was designated as reference unit. The number of reference unit of plants were counted and multiplied by average weight of clipped reference unit to estimate herbaceous biomass production with the following formula. The results were expressed in gram per unit area and after that changed it into kilogram per hectare (Kg.hec^{-1}).

$$Biomass = \frac{\sum_{i=1}^{n} Qi}{P} X R$$

Q=*Weight of total plant species in Quadrate in gram*

n = *Number of plant species in Quadrat*

P = *Area of Quadrate in square meter*

R = *Constant value* (10)

IV. Result

On different viewpoint the estimation of herbaceous biomass for various region and alternative places is important. The research area was divided into four Stands on the basis of altitude due to the uneven nature of area that is mountainous area, plain and small hillocks. Therefore the Biomass of the different area is different at different altitude. There was an increasing trend of biomass up to the spring to winter during 2009 - 2010. However, the collective biomass amount of both herbs and grasses were significantly higher 426.5 Kg.hec^{-1} during spring at Stand 1 as compared to other seasons and Stands. The average grasses and herbs biomass was decreasing with increasing altitude. The herb biomass was high 730 Kg.hec^{-1} during spring at Stand 1 and less during summer (194 Kg.hec^{-1}) at Stand

4. The grass biomass was high 173 Kg.hec^{-1} during summer at Stand 3 and low 74 Kg.hec^{-1} during winter at Stand 1. The total herbs mean biomass was high during spring (536.30 Kg.hec^{-1}) while the grasses had (129.9 Kg.hec^{-1}) during summer. The total average biomass was high at Stand 1 (262.58 Kg.hec^{-1}). The total mean and average biomass of research area was 223.23 Kg.hec^{-1}. (Table 2).

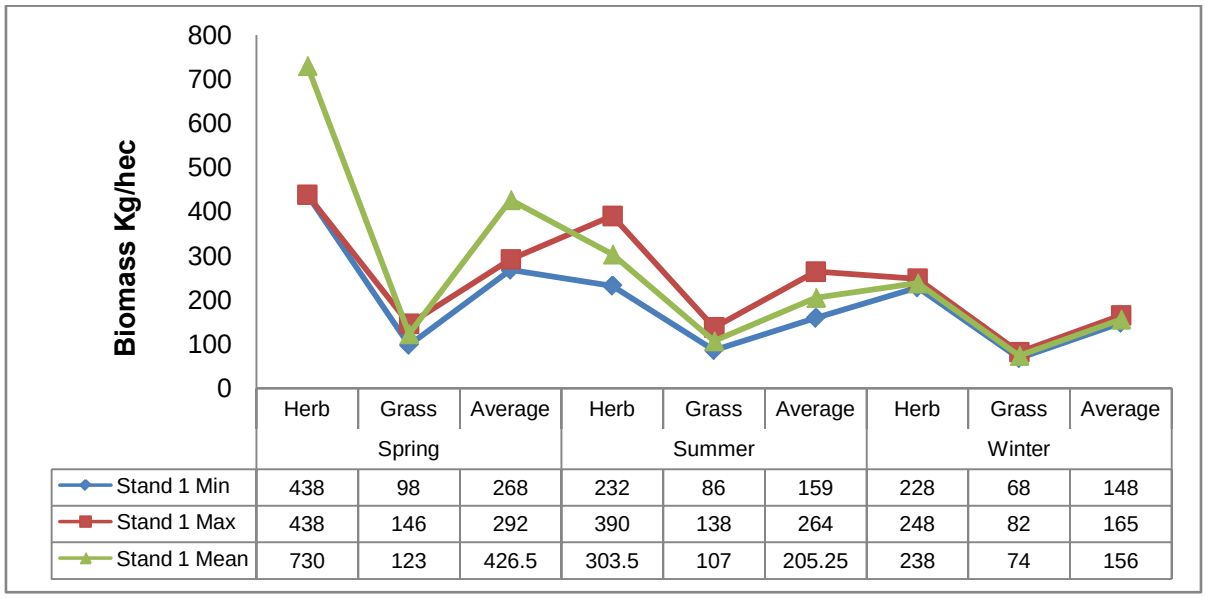
V. Discussion

At Stand 1 the Biomass was high during spring just as it was less throughout winter. In spring the grazing speed was low down in plain area owing to the agriculture place for that reason the plants are present in full span and people of area bring cultured plants for their livestock. In summer the grazing speed is very high so the Biomass turn into less for the period of summer (Fig. 2).

Table 2 : Herbaceous Biomass Means (Kg.hec^{-1}) during different seasons and Stands in 2009- 2010 of Takht-e-Nasrati, District Karak

Seasons	Area / Altitude	Stand 1 340 – 399m	Stand 2 400 – 499m	Stand 3 500 – 599m	Stand 4 600 – 700m	Mean
Spring	Herb	730	426.86	396.85	591.5	536.30
	Grass	123	89.71	84.85	106	100.89
	Average	426.5	258.28	240.85	348.75	318.59
Summer	Herb	303.5	275.4	235	194	251.97
	Grass	107	130.1	173	109.5	129.9
	Average	205.25	202.75	204	151.75	190.93
Winter	Herb	238	222.85	261.43	203.5	231.44
	Grass	74	87.43	109.14	85	88.89
	Average	156	155.14	185.28	144.25	160.16
Total Average		262.58	205.58	210.04	214.92	223.23

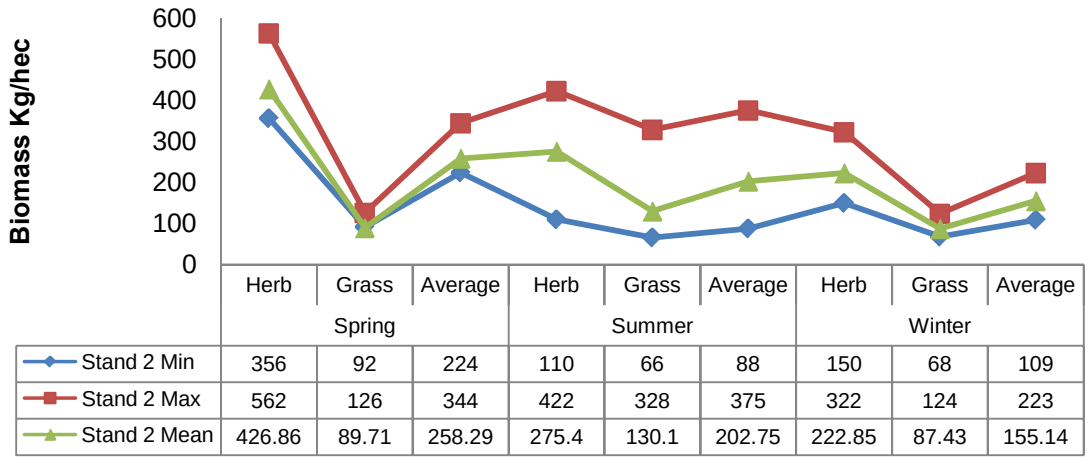
At the end of summer and early winter the rain season started through which the new plants grow but that time the agricultural process become in progress so the farmer cut off herbs and grasses meant for their cattle. The plants loss their masses owing to chilly environment in winter's mid and unavailability of cultivated plants thus the people chosen the natural herbs and grasses for their live stocks. The water table of the area is mostly low as compare to other area of the Tehsil apart from eastern area of Stand 4 someplace the water table is very low so increased the biomass of herbs and grasses. Even though it is usually known that a good association be presents between rainfall and biomass production (Rozenzwieg, 1968; Strickland and Haydock, 1978; Carton et al., 1988; Smuts, 1989), it should, however, be stressed that the production ability of ecotypes can be affected by rainfall factors. It appeared that loss of biomass due to weathering during the winter could, in some situations, be compensated for by harvesting near ground level to include the basal, which would usually be expected to be the heaviest internodes (Boe et al., 2000).



	Herb	Grass	Average	Herb	Grass	Average	Herb	Grass	Average
	Spring			Summer			Winter		
Stand 1 Min	438	98	268	232	86	159	228	68	148
Stand 1 Max	438	146	292	390	138	264	248	82	165
Stand 1 Mean	730	123	426.5	303.5	107	205.25	238	74	156

Fig. 2 : Herbaceous Biomass at Stand 1

In Stand 2, the Biomass was high in spring even as low in winter (Fig. 3). The BIOMASS was low as of Stand 1 for the reason that rainwater which move toward Stand 2 through rain stream are directly go away while stored in the ordinary reservoir in Stand 1 as a result increases the vigor of the plants as will as raise water table of the area. In Stand 2 people obtained fuel and livestock's food from xerophytes like *Zizyphus maurtiana* Lam. and *Acacia modesta* Wall. because the area is mostly desert like so the herbs produce in the area turn into deceased owing the water deficiency. The natives count on rain if in the summer's ending rain happen it takes the green revolution in the area as the summer is very warm and no humidity is there inside earth. The Stand 2 takes up the largest part of the farming field of research area depending on rain. The rainfall is very scanty in the area therefore the famous idiom in the area is "Khattak crush as of one drizzle". Difference of biomass production at different Stands might be due to divergence in climatic conditions, rainfall and soil conditions. It has been reported that the association between climatic conditions subsist, of which rainfall is regarded as the most imperative (Rutherford, 1980).



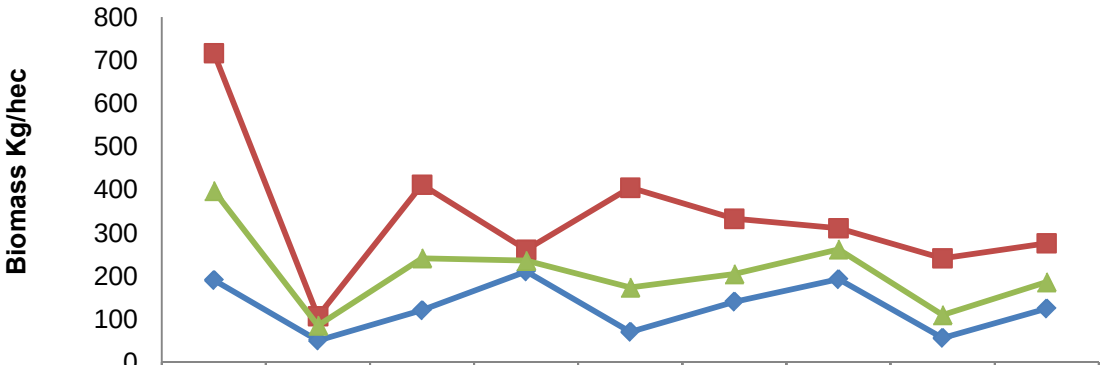
	Herb	Grass	Average	Herb	Grass	Average	Herb	Grass	Average
	Spring			Summer			Winter		
Stand 2 Min	356	92	224	110	66	88	150	68	109
Stand 2 Max	562	126	344	422	328	375	322	124	223
Stand 2 Mean	426.86	89.71	258.29	275.4	130.1	202.75	222.85	87.43	155.14

Fig. 3 : Herbaceous Biomass at Stand 2

The Stand 3 area was consisting of small hills. The area is semi arid as the rain water not store in any part of the area. The Biomass of herbs was also high within spring. The Biomass of grasses was high during summer at the same time as low in spring because the area was often used like natural grass land so the animal preferred the young grasses in spring even as

reverse in summer for the reason that the grasses turn into floral period (Fig. 4).

It explains that the animals preferred the young grasses as contrast to herbs and mature grasses. In winter the herbs and grasses grow to be less because the people of the area cut both herbs and grasses for burning purposes and livestock's food. The area's people are deprived as a result they cut the grasses like *Cymbopogon jwarancusa* (Jones) Schult. and bring into the local bazaar toward solve their economic crisis. For this progression mainly effort was through female. (Fig. 5).

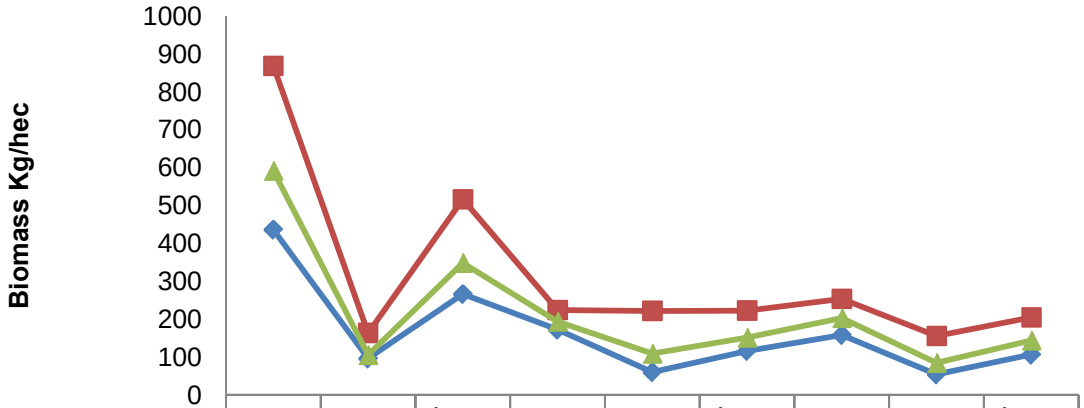


	Herb	Grass	Average	Herb	Grass	Average	Herb	Grass	Average
	Spring			Summer			Winter		
Stand 3. Min	190	50	120	210	70	140	192	56	124
Stand 3. Max	716	106	411	260	404	332	310	240	275
Stand 3. Mean	396.85	84.85	240.85	235	173	204	261.43	109.14	185.285

Fig. 4 : Herbaceous Biomass (Kg.hec $^{-1}$) at Stand 3

Though, the most critical month differed amongst locations and genotype groups differed in their response to moisture availability. Similarly, Muir et al. (2001) reported switch-grass biomass yield was absolutely associated with precipitation during the growing season in Texas. Smart et al. (2005) also pointed out that it is commonly recognized to the amount of April through June precipitation is highly unpredictable and is a strong indicator of the current year's forage production in the northern mixed-grass prairie.

Fig. 5 : Female bring grasses i.e. *Cymbopogon jwarancusa* to solve their economic crisis



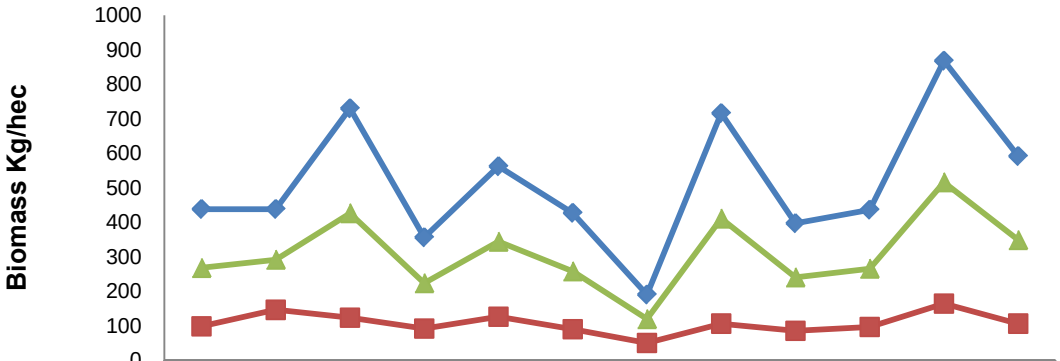
	Herb	Grass	Average	Herb	Grass	Average	Herb	Grass	Average
	Spring			Summer			Winter		
Stand 4. Min	436	96	266	172	60	116	158	54	106
Stand 4. Max	868	164	516	224	222	223	254	156	205
Stand 4. Mean	591.5	106	348.75	194	109.5	151.75	203.5	85	144.25

Fig. 6 : Herbaceous biomass at stand 4

The Stand 4 was the highest region of the Tehsil where the herbaceous Biomass was high in spring and low throughout winter as contrast to further Stands it was high except Stand 1 (Fig. 6). The hills are generally composed of sand and clay so the water accessibility is missing in the hills.

Fig. 7 : Small Dam for water storage at Sarki Lawager

Fig. 8 : Dried well due to low water level.

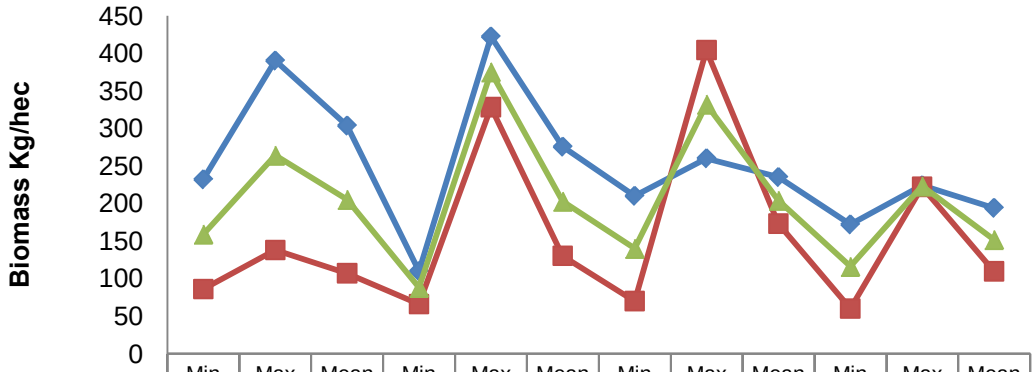


	Stand 1			Stand 2			Stand 3			Stand 4		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Herb	438	438	730	356	562	426.8	190	716	396.8	436	868	591.5
Grass	98	146	123	92	126	89.71	50	106	84.85	96	164	106
Average	268	292	426.5	224	344	258.2	120	411	240.8	266	516	348.7

Fig. 9 : Herbaceous biomass during spring

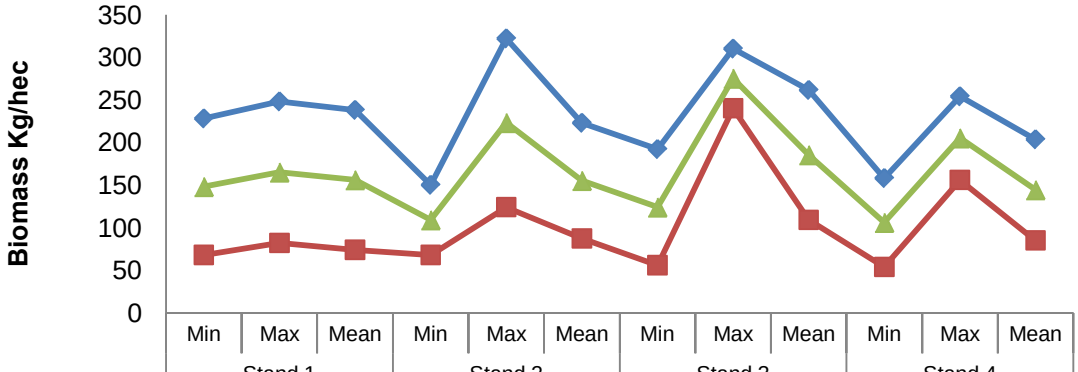
The small dam is in construction at Sarki Lawager however it must be make sure that the hills are formed from rocky stone excluding it will be unsafe on behalf of the region surface close to dam. (Fig. 7). All the way through the dam will raise the water table of the region which turns out to be low in the course of mislay of vegetation (Fig. 8). The grasses and herbs there on hills are smashed in the course of soil erosion. The occurrence of herbs and grasses are very low rate into Stand as the water is unavailable in slopes. The water table of some area is very low but during rain most herbs and grasses are sprint in the rainy water.

Means of Biomass of herbs at different seasons showed significant differences from season to season at different altitude in research area. The BIOMASS of herbs are raised in spring while trim down in winter in Stand 1 and 2 although in Stand 3 & 4 the BIOMASS of herbs are reduced at some stage in summer by reason of the high percentage of grazing progression into these areas. The average BIOMASS of herbs are high during spring while low during winter at all Stands. (Figs . 9, 10, 11 & 12)



	Stand 1			Stand 2			Stand 3			Stand 4		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Herb	232	390	303.5	110	422	275.4	210	260	235	172	224	194
Grass	86	138	107	66	328	130.1	70	404	173	60	222	109.5
Average	159	264	205.2	88	375	202.7	140	332	204	116	223	151.7

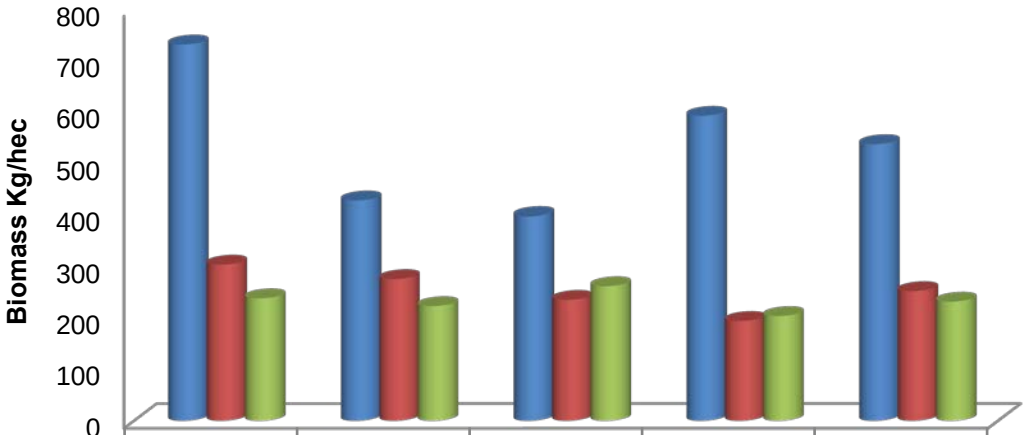
Fig. 10 : Herbaceous biomass during summer



	Stand 1			Stand 2			Stand 3			Stand 4		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Herb	228	248	238	150	322	222.8	192	310	261.4	158	254	203.5
Grass	68	82	74	68	124	87.43	56	240	109.1	54	156	85
Average	148	165	156	109	223	155.1	124	275	185.2	106	205	144.2

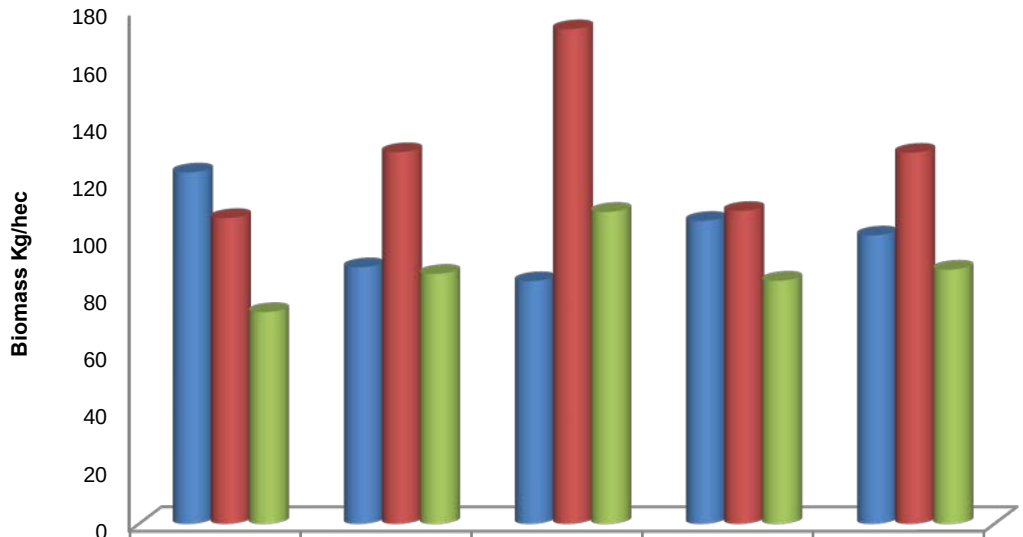
Fig. 11 : Herbaceous biomass during winter

Means for Biomass (kg ha^{-1}) of grasses at different seasons presented in figure 13 showed significant differences for season to season at different altitude in research area. It illustrated that throughout summer the grasses BIOMASS was high at all Stands but Stands 1 where BIOMASS was high during spring as a result of the agriculture approach as well as low grazing rate (Figs. 9, 10, 11 & 13). Cassida et al. (2005) accomplished that water accessibility from April to July was critical for grass biomass production.



	Stand 1	Stand 2	Stand 3	Stand 4	Average
Spring	730	426.86	396.85	591.5	536.3
Summer	303.5	275.4	235	194	251.97
winter	238	222.85	261.43	203.5	231.44

Fig. 12 : Biomass Herbs in different seasons



	Stand 1	Stand 2	Stand 3	Stand 4	Average
Spring	123	89.71	84.85	106	100.89
Summer	107	130.1	173	109.5	129.9
winter	74	87.43	109.14	85	88.89

Fig. 13 : Biomass of grasses in different seasons

VI. Conclusions

The quantity and quality of herbaceous biomass depends on a large number of causes including plant form, plant portion, growing season, growing region, harvesting time, harvesting methods and conversion schemes. Most of these factors can be handled to a definite amount to decrease entire herbaceous biomass. A crucial progress to herb biomass organization for conversion systems is needed that will help develop strategies to decrease the problem of the area in plant adaptation. Tough work should be prepared to put together the approach with valuable exercises of herbaceous biomass, including the potential for production of herbs and grasses to the ground.

VII. Acknowledgment

The paper is a fraction of PhD thesis published as a mandatory towards the award of PhD degree. This study was conducted with the cooperation and efforts of many people of the area. The authors greatly acknowledge the assistance of Muhammad Qasim DM, Government High School Surdag Karak, who contributed to the field work. Special thanks are due to area people and friends that cooperated and assisted throughout the study.

References Références Referencias

1. Ahmad S, Islam M, Bano G, Aslam S and Koukab S. 2009. Seasonal variation in current season and dead Biomass of *chrysopogon aucheri* (boiss) stapf. and *cymbopogon jwarancusa* (jones) schult. in highland Balochistan, Pakistan. *Pak. J. Bot.*, 41(2): 519-527.
2. Boe A, Bortnem R, Kephart KD 2000. Quantitative description of the phytomers of big bluestem. *Crop Sci.* 40: 737-741.
3. Brown RW. 1977. Water relations of range plants. Ch. 4 In: Rangeland Plant Physiology. (Ed.): R.E. Sosebee. Range Sci. Series No. 4. Doc. For Range Manage., Denver, Colo.
4. Carton OT, Brereton AJ, O'Keeffe WF, Keane GP. 1988. Effects of autumn closing date and grazing severity in a rotationally grazed sward during winter and spring. I. Dry matter production, *Irish J. Agric. Res*. 27: 141-150.
5. Cassida KA, Muir JP, Hussey MA, Read JC, Venuto BC, Occumpaugh WR. 2005. Biomass yield and stand characteristics of switchgrass in south central U.S. environments. *Crop Sci.* 45: 673-681.
6. Charley JL. 1972. The role of shrubs in nutrient cycling, Pp. 182-203. In: Wildland shrubs-their biology and utilization. (Eds.): C.M. McKell, J.P. Blaisdell and J.R. Goodwin. USDA Forest Serv. Gen. Tech. Rep. INT-I, Washington, DC.
7. Facelli JM and Pickett STA. 1991. Plant litter: Its dynamics and effects on plant community structure. *Bot Rev.*, 57:2-32.
8. Hussain F and Durrani MJ. 2007. Forage productivity of arid temperate Harboi rangeland, Kalat, Pakistan. *Pak. J. Bot.*, 39(5): 1455-1470.
9. Knapp AK. and Seastedt TR. 1986. Detritus accumulation limits productivity of tallgrass prairie. *Bio. Sci.*, 36: 622-668.
10. Martin RE, Frewing DW. and McClanahan JL. 1981. Average biomass of four northwest shrubs by fuel size class and crown cover. Pacific Northwest Forest and Range Service Experiment Station, USDA Forest Service, Research Note, PNW-374, pp. 6.
11. Moyo B, Dube S, Moyo C. and Nesamvuni E. 2011. Heavily stocked 5-paddock rotational grazing effect on cross-bred Afrikaner steer performance and herbaceous vegetation dynamics in a semi-arid veld of Zimbabwe. *African Journal of Agricultural Research*. 6(10): 2166-2174.
12. Noy-Meir I. 1973. Desert ecosystems: environment and producers. *Annu. Rev. Ecol. Sys.*, 5: 25-51.
13. Olson Bret E. and Richards JH. 1989. Crested wheatgrass growth and replacement following fertilization, thinning, and neighbor plant removal. *J. of Range Mang.*, 42(2): 93-97.
14. Pitt MD. and Heady HF. 1978. Response of annual vegetation to temperature and patterns in Northern California. *Ecology*, 59: 336-350.
15. Rothermel RC. 1972. A mathematical model for predicting fire spread in wildland fuels. USDA Forest Service, Intermountain Forest and Range Experiment Station Research Paper, INT-115, Ogden, UT, 49 pp.
16. Rozenzwieg ML 1968. Net primary production of terrestrial communities: prediction from climatological data. *Am. Nat.* 102: 67- 74.
17. Rutherford MC 1980. Annual plant production, precipitation relations in arid and semi-arid regions. S. Afr. J. Sci. 76: 53-56.
18. Sah JP., Ross MS, Koptur S. and Snyder JR. 2004. Estimating aboveground biomass of broadleaved woody plants in the understory of Florida Keys pine forests. *Forest Ecol. Manag*. 203: 319-329.
19. Saleem A., Mirza SN, Khan IA, Franklin J. 2009. Effect of diverse ecological conditions on biomass production of Themeda triandra (Kangaroo grass) at various growth stages, *African Journal of Biotechnology*, 8 (7): 1233-1237.
20. Smart AJ, Dunn B, Gates R 2005. Historical weather patterns: A guide for drought planning. *Rangelands*, 27: 10-12.
21. Smith W.B. and Gary JB. 1983. Allometric biomass equations for 98 species of herbs, shrubs, and small trees. North Central Forest Experiment Station,

US Department of Agriculture, Research Note, NC-299, pp. 8.
22. Smuts TJ. 1989. Production curves for the six most important grass species in the western part of the grassland biome. Potchefstroom: PU vir CHO, pp. 1-4.
23. Strickland RW, Haydock KP 1978. A comparison of twenty Digitaria accessions at four sites in south-east Queensland. *Aust. J. Experimental Agric. and Ani. Husbandry*, 18: 817-824.
24. Webb W., Szarek S, Lauenroth W, Kinerson R. and Smith M. 1978. Primary productivity and water use in native forest, grassland and desert ecosystems. *Ecology*, 59: 1239-1247.
25. Zhou X., Mahalingam S and Weise D. 2007. Experimental study and large eddy simulation of effect of terrain slope on marginal burning in shrub fuel beds. *Proc.* Combust. Inst. 31: 2547-2555.