DIVERSITY AND SEASONAL VARIATIONS OF FRESH WATER ALGAE IN LUND KHWAR, DISTRICT MARDAN, KHYBER PAKHTUNKHWA PAKISTAN

Usman Ali[1*], Ishrat Begum[1], Abdur Razzaq[1], Abdur Rashid[1], Fazal Hadi[1] and Ikramullah Khan[2]

ABSTRACT

In the present study, 29 species belonging to three divisions (Chlorophyta, Charophyta and Cyanophyta), three classes (Chlorophyceae, Charophyceae and Cyanophyceae), seven orders, 10 families and 13 genera of algae were identified. Among these species 24 (78.57%) belong to Chlorophyta, four (13.7%) to Charophyta and one species i.e. Oscillatoria belongs to Cyanophyta. Spirogyra was the leading genus with nine species followed by Nitella with three species, Cladophora, Chlamydomonas, Ulothrix were represented by two species each. The rest of the genera including Chaetophora, Hydrodictyon, Oedogonium, Tetraedron, Oscillatoria and Chara were represented by single species each. The abundance of algal species was recorded during summer season at temperature of 41°C while the gradual diminishing was noted during winter at 22°C. Highest percentage of species was present where water depth was more. The algal distribution showed that there were diverse groups of algae growing in various microhabitats in the study area.

Key words: *Chara*, charophyta, chlorophyta, Cyanophyta, Khyber Pakhtunkhwa, *Nitella*.

Citation: U. Ali, I. Begum, A. Razzaq, A. Rashid, F. Hadi and I. Khan. 2016. Diversity and seasonal variations of fresh water algae in Lund Khwar, district Mardan, Khyber Pakhtunkhwa Pakistan. Pak. J. Weed Sci. Res. 22(1): 183-195.

INTRODUCTION

Mardan district is part of Peshawar valley, which first appears in history as a part of Gandhara Civilization. Until 1937, Mardan district was a part of Peshawar district. The District lies from 34^0 05/ to 34^0 32/North latitudes to 71^0 48/ to 72^0 25/East longitudes. It is bounded on the north by Buner District and Malakand protected area, on the

[1]Centre of Plant Biodiversity, University of Peshawar, Pakistan
[2]Dept. of Weed Science, The University of Agriculture Peshawar, Pakistan
*Corresponding author's email: usmansssali@gmail.com

East by Swabi and Buner districts, on the South by Nowshera district and on the West by Charsadda district. The summer season is extremely hot; the temperature reaches its maximum in the month of June i.e. 41.5°C. The coldest months are December and January. The mean minimum temperature recorded for the month of January is 21°C. Many historical villages are present here i-e Takhtbhai, Shergarhand, LundKhwar. LundKhwaris the study area literally it means "the ever flowing stream or brooks". Currently it is a major town near the entrance to the Malakand Mountains. The flora of the study area is irrigated, the common trees are Ber and different species of Acacia. Algae cannot be ignored due to its immense importance as primary producers. Algal blooms are the reference primary source of organic matter.

Supporting food webs and among them Cyanophyceans play important role in fixation of atmospheric nitrogen (Pearl *et al.,* 2001). Algae grow in flowing, standing as well as in shallow water, where various factors affect their abundance i.e. some forms of algae also found in stagnant water conditions. Eukaryotic algae and Cyanophyceans (The microphytobenthos) that grow within many shallow water ecosystems form brownish and greenish shading (MacIntyre *et al*., 1996). Algae is economically very important because the efficiency of *Chlorella vulgaris*, *Rhizoclonium hieroglyphicum* and mixed algae culture for biodiesel production by transesterification process and their growth rate was measured on the basis of increase in their dry matter in various media (Ahmad *et al*., 2013). It has been noticed that previously no work has been carried out on the algal biodiversity of Lund Khwar. Therefore, the present studies were carried out to provide base line information for the future research and to fill this academic gap.

MATERIALS AND METHODS

During the present research work more than 6 samples were collected from three different micro habitats i.e. from shallow water with 1 feet in running water (Locality1), standing (Locality 2) and water where the depth was 4 feet (Locality 3) of village Lund Khwar. The collected specimens were preserved in 3% Formalin solution (Sarim *et al*., 2009). For identification different slides were prepared, observed and identified at the laboratory of cryptogrammic plants, Centre of Plant Biodiversity by using microscope. The specimens were taxonomically identified with the help of standard literature i.e. Prescott (1962), Desikachary (1959) and different research articles. For the reference voucher specimens were deposited in University of Peshawar Botanical Garden Herbarium (UPBG).

RESULTS AND DISCUSSION

The collections were made from different sites i.e. some water were shallow where sunlight could penetrate up to bottom and depth up to 1 foot, some specimens collected from water where water depth was more than 4 feet. Thereare some ditches surrounded the main stream where water remains standing in some periods of a year.

A total of 11 genera with 29 species were identified belonging to 3 classes (Chlorophyceae, Cyanophyceae and Charophyceae), 7 orders and 10 families. They have been systematically arranged (Table-1) according to proposed classification (Prescott, 1951; Desikachary, 1959 andZaman and Sarim 2005).

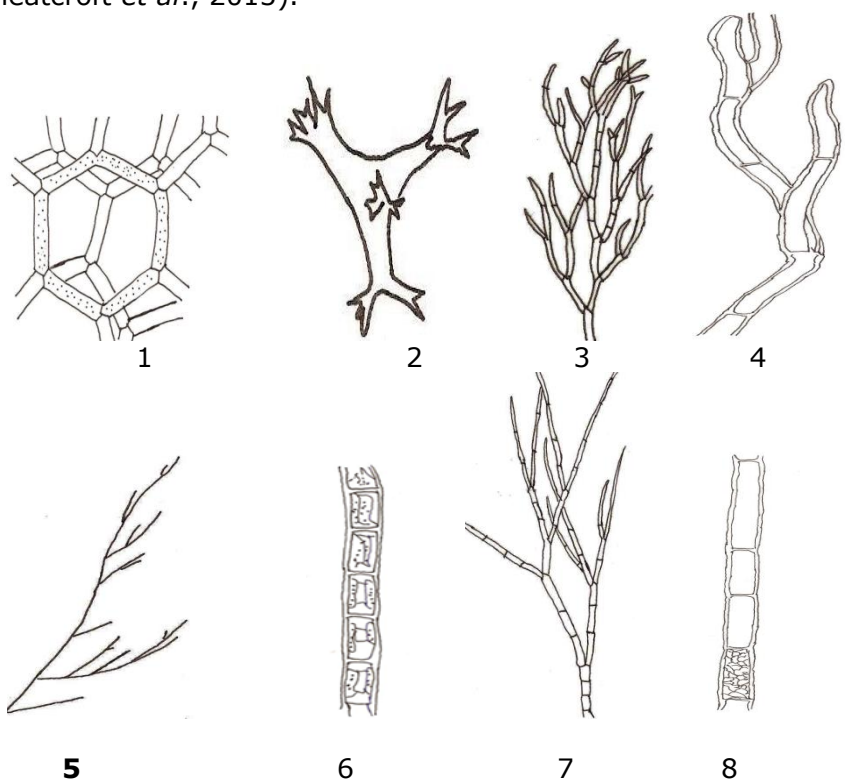
Chlorophyceae was the leading class with 24 (82.7%) species, five (71.4%) orders and seven (70%) families. Class Cyanophyceae was represented by only 1 (4.16%) species, 1 (14.2%) order (Nostocales) and 1 (10%) family; whereas Charophyceae with 4 (4.16%) species, 1 (14.2%) order and 2 (20%) family. Among these Chlorophyceae was dominant class containing highest percentage of species both in summer as well as in winter season.

During summer season (Table-2 & 4) 14 species (48.27%) of Chlorophyceae were present in locality number one. Nine (9) species (31.03%) in locality number two and 22 species (75.86%) were present in locality number three. One species (4.16%) of Cyanophyceae was present in locality number two and not prevails in locality number one and three. Member of Cyanophyceae found in free floating state forming scum changing their nature of occurrence depending upon habitat conditions (Naz *et al.,* 2004). The richness of algal species occurs during summer season. The size of phytoplankton is an effective indicator of the ecosystem and variation in size is due to change in water dynamics (Wang *et al*., 2014).

During winter season (Table-3 and 4) 6 species (20.68%) of Chlorophyceae were present in locality number 1, 3 species (10.34%) were present in locality number 2 and 13 species (44.82%) were present in locality number 3. 1 species (4.16%). Cyanophyceae was present in locality 2 and absent in locality 1 and 2. The gradual diminishing of algal species was noted during winter season. Many species of *Spirogyra* were found in summer season as compared to winter. Similarly, in summer season (Table-5), 14 species (48.27%) of Chlorophyceae were present in locality number 1, 9 species (31.03%) were present in locality number 2 and 22 species (75.86%) werepresent in the locality number 3. While 1 species (4.16%) each of Cyanophyceae was present at localities 2 and 3 while no species was present at locality 1.

The diversity of macro algae was high in summer season as compare to winter season and is the main food source for a large number of herbivores (Kaehler *et al.,* 1996).

Chara and *Nitella* are macro species and found in winter season both in shallow and standing water. Micro algae having higher growth productivity, higher lipid contents, non-competitive nature with human food and their ability to grow on non-arable land using brackish and used for the production of biofuel (Gill *et al.,* 2013). The difference in the percentage of species in different localities is due to different environmental conditions like pH, light penetration due to depth and turbidity of water and temperature. Such findings are supported by in a variety of ponds at Rawal Dam (Laghari *et al*., 2005). Algal bloom are more frequently present in summer season as compared to winter season this may be due to Seasonal variation (temperature, rainfall, pH, Light intensity) effect chlorophyll a content in microphytobenthos (Wheatcroft *et al*., 2013).



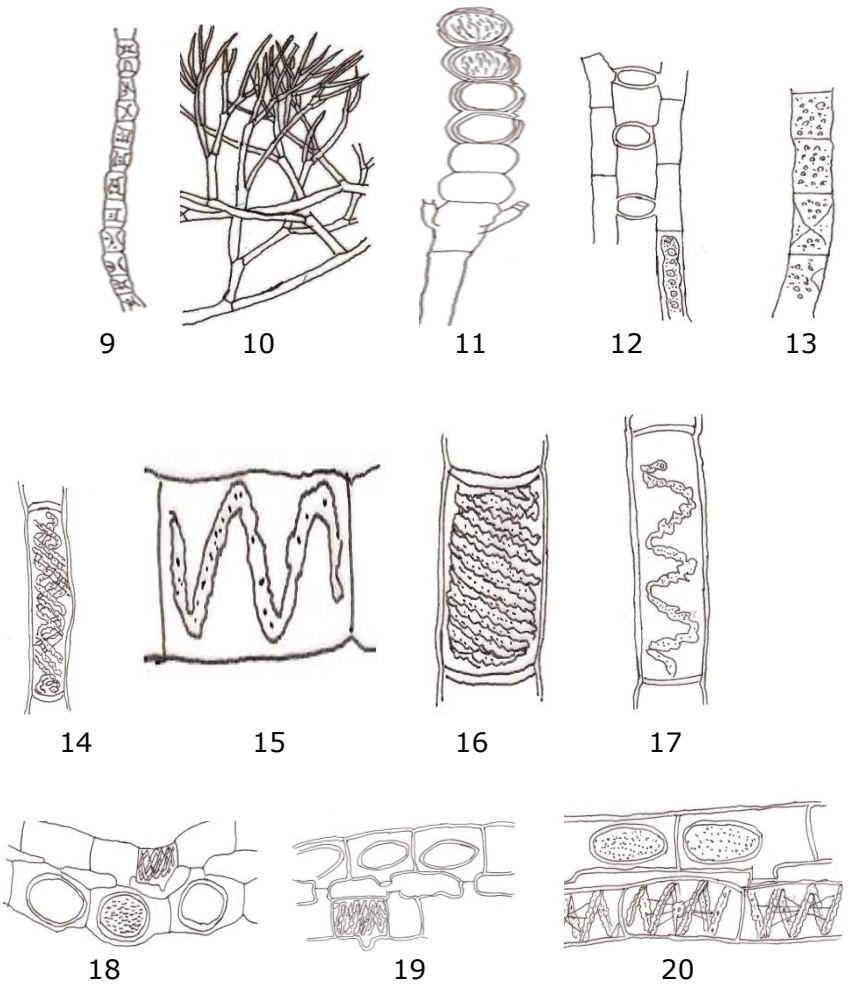
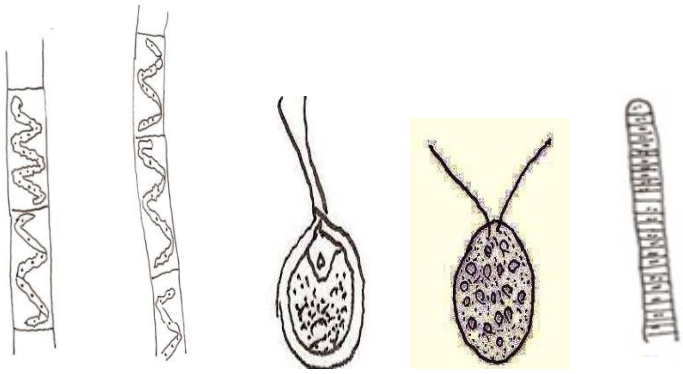


Figure 1 to 20.
1. *Hydrodictyon reticulatum* (x75) **2.** *Tetraedron limneticum (*x650) **3.** *Cladophora glomerata* (x200) **4.** *Rhizoclonium fontanum* (x440) **5.** *Cladophora crispate* (x200) **6.** *Chaetophora elegans* (x225) **7.** *Stigeoclonium subsecundum* (x440) **8.** *Rhizoclonium crassipellitum* (x150) **9.** *Ulothrix subtilissima (*x750*)* **10.** *Ulothrix aequalis* (x500) **11.** *Oedogonium striatum* (x175) **12.** *Mougeotia robusta* (x250)**13.** *Mougeotia scalaris* (x500) **14.** *Spirogyra aequinoctialis* (x375) **15.** *Spirogyra borgeana (*x285*)* **16.** *Spiroxgyra candensata (*x275*)* **17.** *Spirogyra crassa* (x62) **18.** *Spirogyra ellipsospora* (x600) **19.** *Spirogyra fluviatilis* (x280) **20.** *Spirogyra porticalis* (x400).



21 22 23 24 25

26 27 28 29

Figure 21 to 29:
21. *Spirogyra scrobiculata* (x440) **22.** *Spirogyra varians* (x350) **23.** *Chlamydomonas* pseudopertyi (x500) **24.** *Chlamydomonas polypyrenoideum* (x1000) **25.** *Oscillatoria subbrevis* (x750) **26.** *Chara vulgaris* (x40) **27.** *Nitella flexilis* (x30) **28.** *Nitellaopaca* (x5) **29.** *Nitella tenuissima* (x5)

Table-1. Algal Diversity in microhabitats of Kabla Khwar of village Lundkhwar, District Mardan.

S.No.	ORDER	FAMILY	SPECIES
CLASS CHLOROPHYCEAE			
1.	Chlorococcales	Hydrodectaceae	*Hydrodictyon reticulatum* (L.) Lagerheim
		Oocytaceae	*Tetraedron limneticum* Borge
2.	Cladophorales	Cladophoraceae	*Cladophora crispata* (Roth) Kuetzing
			Cladophora glomerata (L.) Kuetzing
			Rhizoclonium crassipellitum West & West
			*Rhizoclonium fontanum*Kuetzing
3.	Oedogoniales	Oedogoniacea	*Oedogonium striatum* Tiffany
4.	Ulotricales	Ulotriceae	*Ulothrix aequalis* Kuetzing
			Ulothrix subtilissima Rabenhorst
		Chaetophoraceae	*Chaetophora elegans* (Roth) C. A. Agardh
			Stigeoclonium suhsecundum Kuetzing
5.	Zygnematales	Zygnemataceae	*Mougeotia robusta* var. hiornata Wittrockin Wittrock & Ordstedt
			Mougeotia scalaris Hassall
			*Spirogyra aequinoctialis*G. S. West
			*Spirogyra borgeana*Transeau
			Spirogyra candensata (Vauch.)Kuetzing
			*Spirogyra crassa*Kuetzing
			*Spirogyra ellipsospora*Transeau
			*Spirogyra fluviatilis*Hilse in Rabenhorst
			Spirogyra porticali (Muell) Cleve
			Spirogyra scrobiculata (stock.) Czurda
			*Spirogyra varians (Hass.)*Kuetzing
6.	Volvocalles	Chlymydomonadace	*Chlamydomonas pseudopertyi* Pascher
			Chlamydomonas polypyrenoideum Prescott
CLASS CYANOPHYCEAE			
7.	Nostocales		

		Oscillatoriaceae	*Oscillatoria subbrevis* Schmidle
CLASS CHAROPHYCEAE			
8.	Charales	Characeae	*Chara vulgaris* Linnaeus
			Nitella flexilis (L.) C. A. Agardh
			Nitella opaca C. A. Agardh
			Nitella tenuissima (Desv.) Kuetzing

Table-2. Algal diversity in three different localities during summer season at temperature of 41 ^{0}C.

S.No.	Classes with species	Loc.1	Loc. 2	Loc. 3
	CHLOROPHYCEAE			
1.	*Cladophora crispata* (Roth) Kuetzing	+	+	+
2.	*Cladophora glomerata* (L.) Kuetzing	+	+	+
3.	*Chlamydomonas polypyrenoideum* Prescott	-	-	-
4.	*Chlamydomonas pseudopertyi*Pascher	-	-	-
5.	*Chaetophora elegans (Roth)* C. A. Agardh	+	+	+
6.	*Hydrodictyon reticulatum*(L.) Lagerheim	-	-	+
7.	*Mougeotiaro busta* var. hiornata Wittrock	+	+	+
8.	*Mougeotia scalaris* Hassall	+	+	+
9.	*Oedogonium striatum* Tiffany	-	-	+
10.	*Rhizoclonium crassipellitum* West and West	-	-	+
11.	*Rhizoclonium fontanum*Kuetzing	-	-	+
12.	*Spirogyra aequinoctialis* G. S. West	-	-	+
13.	*Spirogyra borgeana*Transeau	+	-	+
14.	*Spirogyra candensata* (Vauch.) Kuetzing	+	-	+
15.	*Spirogyra crassa* Kuetzing	-	-	+
16.	*Spirogyra ellipsospora* Transeau	+	-	+
17.	*Spirogyra fluviatilis*Hilse in Rabenhorst	+	-	+
18.	*Spirogyra porticalis* (Muell.) Cleve	+	+	+
19.	*Spirogyra scrobiculata* (stock.) Czurda	+	-	+
20.	*Spirogyra varians* (Hass.) Kuetzing	+	-	+
21.	*Stigeoclonium suhsecundum* Kuetzing	-	-	+

22.	*Tetraedron limneticum* Borge	-	+	+
23.	*Ulothrix aequalis* Kuetzing	+	+	+
24.	*Ulothrix sutilissima* Rabenhorst	+	+	+
	CYANOPHYCEAE			
25.	*Oscillatoria subbrevis* Schmidle	-	+	+
	CHAROPHYCEAE			
26.	*Chara vulgaris* Linnaeus	-	-	-
27.	*Nitella flexilis* (L.) C. A. Agardh	-	-	-
28.	*Nitella opaca* C. A. Agardh	-	-	-
29.	*Nitella tenuissima* (Desv.) Kuetzing	-	-	-

Table-3. Algal diversity in three different localities during winter season at temperature of 22°c.

S.No.	Classes with species	Loc 1	Loc 2	Loc 3
	CHLOROPHYCEAE			
1.	*Cladophora crispata* (Roth) Kuetzing	-	-	+
2.	*Cladophora glomerata* (L.) Kuetzing	-	-	+
3.	*Chlamydomona spolypyrenoideum* Prescott	-	+	-
4.	*Chlamydomonas pseudopertyi* Pascher	-	+	-
5.	*Chaetophora elegans* (Roth) C. A. Agardh	-	-	-
6.	*Hydrodictyon reticulatum* (L.) Lagerheim	-	-	-
7.	*Mougeotia robusta* var. hiornataWittrock	+	-	+
8.	*Mougeotia scalaris* Hassall	+	-	-
9.	*Oedogonium striatum* Tiffany	+	-	+
10.	*Rhizoclonium crassipellitum* West	-	-	+
11.	*Rhizoclonium fontanum* Kuetzing	-	-	+
12.	*Spirogyra aequinoctialis* G. S. West	-	-	-
13.	*Spirogyra borgeana*Transeau	-	+	+
14.	*Spirogyra candensata* (Vauch.) Kuetzing	-	-	-
15.	*Spirogyra crassa* Kuetzing	+	-	+
16.	*Spirogyra ellipsospora* Transeau	-	-	-
17.	*Spirogyra fluviatilis*Hilse in Rabenhorst	-	-	-

18.	*Spirogyra porticalis* (Muell.) Cleve	-	-	-
19.	*Spirogyra scrobiculata* (stock.) Czurda	-	-	-
20.	*Spirogyra varians* (Hass.) Kuetzing	-	-	+
21.	*Stigeoclonium subsecundum* Kuetzing	-	-	+
22.	*Tetraedronlim neticum* Borge	-	-	+
23.	*Ulothrix aequalis* Kuetzing	+	-	+
24.	*Ulothrix subtilissima* Rabenhorst	+	-	+
	CYANOPHYCEAE			
25.	*Oscillatoria subbrevis* Schmidle	-	+	-
	CHAROPHYCEAE			
26.	*Chara vulgaris* Linnaeus	+	+	-
27.	*Nitella flexilis* (L.) C. A. Agardh	+	+	-
28.	*Nitella opaca* C. A. Agardh	+	+	-
29.	*Nitella tenuissima* (Desv.) Kuetzing	+	+	-

Table-4. Percentage of algal species in different localities in winter.

S.No.	Classes	Number/Percentage	Locality 1	Locality 2	Locality 3
1.	Chlorophyceae	Number of species	6	3	13
		% of species	20.68	10.34	44.82
2.	Cyanophyceae	Number of species	Nil	1	Nil
		% of species	0	4.16	0
3.	Charophyceae	Number of species	4	4	Nil
		% of species	13.7	13.7	0

Table-5. Percentage of algal species in different localities in summer

S.No.	Classes	Number/Percentage	Locality 1	Locality 2	Locality 3
1.	Chlorophyceae	Number of species	14	9	22
		% of species	48.27	31.03	75.86
2.	Cyanophyceae	Number of species	Nil	1	1
		% of species	0	4.16	4.16

REFERENCES CITED

Ahmad, F., A.U. Khan and A. Yasar. 2013. Transesterification of oil extracted from different species of algae for biodiesel production. Afr. J. Environ. Sci. Technol. 7(6): 358-364.

Akthar, K.P., S. Ghulam, G. Abbas, J.A. Muhammad, N. Sarwar, T.M. Shah. 2011. Screening of mungbean germplasm against mungbean yellow mosaic India virus and its vector *Bemisia tabaci*. Crop Protec. 30(9): 1202-1209.

Ara, M.R., M.M. Masud and A.M. Akanda. 2012. Detection of plant viruses in some ornamental plants that act as alternate hosts. The Agric. 10(2): 46-54.

Cavalla, L.L. 1952. An analysis linkage in quantitative inheritance (Eds.) E.C.R. Reeve and C.H. Waddington. HMSO. London, Pp. 135-44.

Daughtry, C.S.T and S.F. Hollinger. 1983. Costs of measuring leaf area index of com. Agron. J. Repub. S. Africa. 76: 836-841.

Desikachary, T.V. 1959. Cyanophyta, Indian Council of Agricultural Research, New Delhi. 686 pp.

Eastham, J., D. M. Oosterhuis and S.Walker. 1983. Leaf water and Turger potential. Tresshold values for leaf growth of wheat. Agron. J.R.S. Africa*,* 76: 841-847.

Gill, S.S., M. A. Mehmood, U. Rashid, M. Ibrahim, A. Saqib and M.R. Tabassum. 2013. Waste-water treatment coupled with biodiesel production using microalgae: A Bio-refinery approach. Pak. J. Life Social Sci. 11(3): 179-189.

Goplan. C., B. V.R Sastri and S.C. Subramanian. 2007. Nutrition value of Indian foods. National Institute of nutrition, Hyderabad, ICMR.P. 161.

Ilyas M., J. Qazi, S.Mansoor and R.W. Briddon 2009. Molecular characterization and infectivity of a "Legumovirus" (genus Begomovirus: family Geminiviridae) infecting the leguminous weed Rhynchosia minima in Pakistan. Virus Res. 145:279_284.

Kaehler, S. and R. Kennish. 1996. Summer and winter comparisons in the nutritional value of marine macro algae from Hong Kong. Botanica Marina, 39(1-6): 11-18.

Kang BC, Yeam I, Jahn MM. 2005. Genetics of plant virus resistance. Annu. Rev. Phytopathol. 43:581_621.

Khattak, G.S.S; S.A. Rana, T. Elahi and P. Srinives. 1998. An efficient crossing technique for crossing mungbean (*Vigna radiata* (L.) Wilczek). Thai. J. Agric. Sci. 31(4): 577-582.

Khattak, G.S.S; M.A. Haq, M. Ashraf and P. Srinives. 2001. Combining ability in mungbean (*Vigna radiata*(L). Wilczek) Agronomic traits. Korean J. Crop. Sci. 46: 420-423.

Khattak, G.S.S; M.A. Haq, M. Ashraf and Hassan. 2002. Detection of epistasis and estimation of additive and dominance components of genetic variation for determinate growth habit in mungbean (*Vigna radiata*(L.) Wilczek). J. Gene. Breed. 56: 1-7.

Khattak, G.S.S., M. Ashraf and R. Zamir. 2004. Gene action for synchrony in pod maturity and inheritance growth habit in mungbean (*Vigna radiata* (L.) Wilczek). Pak. J. Bot. 36(3): 589-594.

Khattak, G.S.S.; M. Ashraf and M.S. Khan. 2004a. Assessment of genetic variation for yield and yield components in mungbean (*Vigna radiata* L.) wilczek) using generation mean analysis.

Kudre, T.G., S. Benjakul, and H. Kishimura. 2013. Comparative study on chemical composition and properties of protein isolates from mungbean, blackbean and bambara groundnut. J. Sci. Food. Agric. 93: 2429-2436.

Laghari, M.K, M. Shah and M.Y. Leghari. 2005. Ecological study of blue-green algae from RawalDamWater, Islamabad. Int. J. Phycol. Phytochem. 1: 5-12.

MacIntyre, H.L., R.J. Geider and D.C. Miller. 1996. Microphytobenthos: the ecological role of the "secret garden" of unvegetated, shallow-water marine habitats. I. Distribution, abundance and primary production. Estuaries. 19(2):186-201.

Malathi, V.G. and P. John. 2008b. Mungbean yellow mosaic viruses. *In*: Mahy BWJ, Van Regenmortel MHV, editors. Desk encyclopedia of plant and fungal virology in encyclopedia of virology, Vol. 8. Amsterdam: Elsevier; 364-371.

Malik, B.P.S. and V.P. Singh. 1983. Genetics of some metric traits in green gram. Ind. J. Agric. Sci. 53: 1002-1005.

Naz, S., M. Hasan and M. Shameel. 2004. Biodiversity ofOscillatoria (Nostocophyceae, Cyanophyta) from northern areas of Pakistan. Pak. J. Bot. 36(3): 503-530.

Paerl, H. W., R. S. Fulton, P. H. Moisander and J. Dyble. 2001. Harmful freshwater algal blooms, with an emphasis on cyanobacteria. The Sci. World J. 1:76-113.

Prescott, G.W. 1962 Algae of the Western Great Lakes Area. 2nded W. C Brown. Co. Dubuque, lowa 997 pp.

Ram, T. 1997. Gene action for certain quantitative characters in green gram (*Vigna radiata* (L.) Wilczek). Indian J. Gen. 57(2): 143-148.

Sandhu, K.S. and S.T. Lin. 2008. Digestibility of legume starches as influenced by their physical and structural properties. Carbohydr. Polym. 91: 243-252.

Singh, S. and R.B. Singh. 1976. Triple test cross analysis in two wheat crosses. Heredity. 37: 173-177.

Singh, A. and K.P. Singh. 1996. Genetic analysis of three mungbean crosses involving parents with different photo-thermal response for grain yield and component traits. Ind. J. Gen. Pl. Breed. 56(3): 329-334.

Wang, G and W. Cao. 2014. The seasonal variation of the phytoplankton size class in northern South China Sea.In *IOP Conference Series:* Earth Environ. Sci. 17(1): 23-27.

Wheatcroft, R.A., R.D. Sanders and B.A. Law. 2013. Seasonal variation in physical and biological factors that influence sediment porosity on a temperate mudflat: Willapa Bay, Washington, USA. Cont. Shelf Res. 60:173-184.