**Biodiversity and correlation studies among various traits of** *Digeria arvensis, Cyperus rotundus, Digitaria adescendense and Sorghum halepense*

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**Abstract:** The prescribed study was carried out to access the weeds for plant population and plant moisture percentage. Data of *Digeria arvensis, Cyperus rotundus, Digitaria adescendense and Sorghum halepense*from three places of four locations *viz*., Centre of Excellence in Molecular Biology, University of the Punjab Lahore, Institute of Agricultural Sciences (IAGS), University of the Punjab Lahore, Hanjerwal colony near Centre of Excellence in Molecular Biology, University of the Punjab Lahore and Road side area of Ferozepur Road Kasur. It was found that higher plant population was recorded for *Cyperus rotundus*, higher moisture percentage in the plant body and inflorescence was recorded for *Digeria arvensis*. The weed plants population per square meter was significantly correlated with all studied traits. Fresh inflorescence weight was strongly and significantly correlated with dry plant weight, dry inflorescence weight, total plant moisture percentage and inflorescence moisture percentage. The strong and significant correlation of total plant moisture percentage and inflorescence moisture percentage with other traits indicated that there is important association among the weeds with respect to all locations. It was suggested that the weed controlling measuring practices should be carried out to minimize the yield losing effects of weeds. The herbicide resistant crop varieties should be developed to control weeds.

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**1. Introduction**

The term weeds referred as any plant that grows at unwanted place. Taxonomically, the term "weed" has no botanical significance due to the fact that a plant which is a weed in at one place may be not a weed when growing in a situation where it is in fact wanted. Weeds are big issue in crop cultivation because it causes reduction in crop yield: Weeds starts to compete with our precious crop for water, nutrients and light (David 1998). As they are hardy and have vigorous growth habit, they outgrow the crops soon & consume large amounts of water and nutrient that cause heavy losses in yield. It may increase the cost of cultivation. Quality of the field produce also reduced. Weeds also give shelter to various insect pests & disease pathogens and they may serve as alternate hosts for spread of pest and disease (Qamar *et al*., 2015). Besides all these facts they also hinder the beautification of lawns and recreational parks. Weed seeds can be spread in a number of ways i.e. wind, water, animals, poor quality grass seed and garden and lawn equipments. Almost all weed seeds remain dormant even for years and initiates their germination when they met favorable conditions for germination (Janick 1979; Townsend 1985; Robert and Chanthy, 2009).

* 1. ***Digeria arvensis***

*Digeria arvensis*, also known as cotton weed and Kunjaru is an annual herb that belongs to family Amaranthaceae. It grows abundantly in Subtropical Asia and eastern tropical Africa. It is commonly found in waste areas. It grows upto 70 cm tall, and have simple or may be branched stem, which is subglabrous in shape but ridged in structure. Leaves of this weed are alternate and simple, their petiole grows upto 5 cm in length, they are blade like in shape and are linear to ovate, their base is narrow, have acuminated apex. In inflorescence they contain a long-peduncle (may be up to 14 cm in length), have spike-like bracteate raceme that appears on axils and grows up to 30 cm long. Each of them unites to form a sub-sessile partially looked inflorescence which has a central fertile flower with 2 lateral sterile flowers. Their hairless, white to pink color flowers are borne on slender spike-like racemes that can 30 cm large (Seshadri and Nambia 2003).

* 1. ***Cyperus rotundus***

*Cyperus rotundus* (derived from Greek words, kyperos and rotundus is from Latin, meaning "round"), the most protruding weed, commonly also known as Java grass, nut grass, purple nut sedge, red nut sedge and Khmer Kravanh chruk and “worst weed”, is perennial plant which belongs to sedge (family Cyperaceae). It is native of Africa, Southern and Central Europe and Southern Asia and damage crops by their allelopathic effect. It have intensive root system which provides it support to grow vigorously and thus it can reach upto height of 140cm. Leaves of Cyperus sprouts in the rank of 3 from the base of plant and grows about 5-20cm long having triangular cross section stem. Flower is bisexual having 3 stamens and 3 stigma carpel, also contain 3-8 unequal rays of flower head (Santos *et al*., 1998). Fruit is also 3-angled achene. Young plant initially exhibits fleshy rhizome as root system which usually forms the chain of 25mm dimension. Some rhizomes may grow upward in the soil which then forms a bulb like structure from which the new growth occurs. Other rhizomes grow horizontally or under the soil, that forms dark reddish-brown tuber or chains of tubers. It prefers dry conditions but can also grow in wet areas (Travlos *et al*., 2009; Shabana *et al*., 2010; Elahi *et al*., 2011a).

* 1. ***Digitaria adescendense***

*Digitaria adescendense* being an annual grass is damaging to our crops as have advantage to grow even on less fertile lands and their drought resistance makes them possible to stand in almost every type of soil which extends its own root system by weakens the root system of surrounding plants. It has thin and narrow radiating branches at the top of stem which are usually 9 in number. A pair of spikelet is present on the terminal portion of each branch. The color of their inflorescence is reddish to purple. The table below shows how much water *Digitaria adescendense* consumes (Heatwole 1981).

* 1. ***Sorghum halepense***

*Sorghum halepense*, a perennial plant, commonly known as Johnson grass belongs to Poaceae family is the native of Mediterranean regions but due to drought tolerace grows almost all over the world except Antarctica and archipelagos. It grows upto 50-200cm tall due to strong support of its creeping rhizome. It has pre-eminently white color midrib in leaf blade. The spikelets are sessile and appear in the form of pair which is 4.5-5.5 mm long that when grows, gives falling down look. The table below shows how much water *Sorghum halepense* consumes (Martin and Cox 1984; Holm *et al*., 1997; Elahi *et al*., 2011b).

1. **Materials and Methods**

The present study was conducted at Centre of Excellence in Molecular Biology, University of the Punjab Lahore, Pakistan during March 2015. The of *Digeria arvensis, Cyperus rotundus, Digitaria adescendense and Sorghum halepense* weeds was collected from 4 different locations *viz*. Centre of Excellence in Molecular Biology, University of the Punjab Lahore, Institute of Agricultural Sciences (IAGS), University of the Punjab Lahore, Hanjerwal colony near Centre of Excellence in Molecular Biology, University of the Punjab Lahore and Road side area of Ferozepur Road Kasur. The data was recorded for fresh plant weight, fresh inflorescence weight, dry plant weight, dry inflorescence weight by using an electronic balance (OHAUS-GT4000, USA), total plant moisture percentage [(fresh plant weight – dry plant weight)/fresh plant weight\*100], total inflorescence moisture percentage [(fresh inflorescence weight - dry inflorescence weight)/ fresh inflorescence weight\*100] and number of plants per square meter area. The data was statistically analyzed by using analysis of variance technique (Steel *et al*., 1997).

1. **Results and discussions**

It was found from table 1 that significant differences among all studied traits of weeds. It was also indicated from results that significant weeds × location interaction were found for all traits. Significant interactions suggested that the weeds have significant correlation with their biodiversity at various locations of the world. The weeds can grow at all locations along with the competition of crop plants and environmental conditions. The relation of weeds with locations indicated that the weeds can easily grow under various environmental conditions. It was indicated from results that average dry plant weight of all four studied locations was recorded to be 5.03±0.071g while fresh plant weight was found as 13.446±0.129. The average dry inflorescence weight was found as 0.5266±0.0573g while fresh inflorescence weight was 3.53±0.0881. The average number of plants at all locations was 50.74±7.6171. The total moisture percentage in plant body was recorded as 71.541±0.7183% while inflorescence moisture percentage was found as 79.71±2.1802%. The higher moisture percentage in whole plant body suggested that the weeds used higher water. The higher water use percentage also suggested that the weeds may cause loss of water and nutrient contents from soil that leads towards the loss of crop yield. The use of herbicides (glyphosate) to control weeds may cause the loss of crop plants, therefore the improvement of glyphosate resistance in crop plant is needed in order to reduce the loss of crop plant yield due to weeds (Elahi *et al*., 2011ab, Qamar *et al*., 2015).

It was found from table 2 that higher number of plant per square meter of *Cyperus rotundus* were recorded at Hanjerwal (45.22), Institute of Agricultural Sciences University f the Punjab (120.87), CEMB (100.81) and Kasur (123.67) at all studied locations while lowest number of plants were found for *Sorghum halepense* Hanjerwal (10.98), Institute of Agricultural Sciences University f the Punjab (58.67), CEMB (35.56) and Kasur (9.87). The higher population of *Cyperus rotundus* at all locations indicated that the ability of *Cyperus rotundus* to compete with other weeds and crop plants is higher and may caused loss of crop yield plants. The results indicated that higher fresh plant weight and dry plant weight was found for *Sorghum halepense* at CEMB (34.838g, 15.977g), Hanjerwal (33.430g, 15.610g), Punjab University (32.853g, 15.207) and Kasur (33.070g, 15.440g) respectively. The lower fresh plant weight and dry plant weight was found for *Digitaria adscendense* at CEMB (4.920g, 1.400g), Hanjerwal (4.097g, 1.327g), Punjab University respectively. The results from table 2 indicated that *Cyperus rotundus* showed higher fresh inflorescence weight at CEMB (4.707g), Hanjerwal (4.447g), Punjab University (4.327g) and Kasur (5.00g) while lowest was found for *Digitaria adscendense* at CEMB (4.097g) and *Sorghum halepense* at Hanjerwal (1.273g), Punjab University (0.737g) and Kasur (1.143g). Higher dry inflorescence weight was found for *Digeria arvensis* at Hanjerwal (0.703g), Punjab University (0.767g) and Kasur (1.033g) while *Sorghum halepense* at CEMB (0.717g). The moisture percentage in the plant body and inflorescence was recorded for *Digeria arvensis* at CEMB (83.243%, 83.615%), Hanjerwal (85.487%, 83.893%), Punjab University (87.538%, 82.576%) and Kasur (85.845%, 77.857%) respectively. Lowest moisture percentage in the plant body and inflorescence was recorded *Sorghum halepense* at all locations. The higher moisture percentage in the weed body indicated that the ability of weeds to store and use water was higher. The absorption of nutrients from soil are also higher that caused the loss of availability of nutrients to the crop plants and effect the decrease in yield of crop plants. It was suggested that to control the losses of crop yield due to weeds should be improved through cultural and chemical control through the use of herbicide resistant crop varieties (Shabana *et al*., 2010; Ali *et al*., 2013; Ali *et al*., 2014ab).

It was found from table 3 that strong and significant correlation of dry plant weight was fresh plant weight, total plant moisture percentage, inflorescence moisture percentage, inflorescence fresh and dry weight and number of plant per square meter. The number of weed plants per square meter was significantly correlated with all studied traits. Fresh inflorescence weight was strongly and significantly correlated with dry plant weight, dry inflorescence weight, total plant moisture percentage and inflorescence moisture percentage. The strong and significant correlation of total plant moisture percentage and inflorescence moisture percentage with other traits indicated that there is important association among the weeds with respect to all locations. The yield losing effect of weeds on crop plants may have similar affects. The higher plant moisture percentage suggested that the weeds used much of soil water and nutrients that caused reduction in nutrients availability to crop plants. The increase in number of weed plant population caused competition with crop plants and reduced yield and quality of required field crop plants (Shabana *et al*., 2010; Ali *et al*., 2013; Ali *et al*., 2014ab). By controlling weeds the crop yield may be improved.

**Table 1. ANOVA for various studied traits of weeds**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Source** | **DF** | **Dry plant** **weight** | **Inflorescence** **Dry weight** | **Fresh plant** **weight** | **Inflorescence** **Fresh weight** | **No of plants** | **Total plant** **moisture** **percentage** | **Total inflorescence** **moisture percentage** |
| **Replications** | 2 | 0.4608 | 0.00165 | 0.4008 | 0.1052 | 0.1152 | 0.00135 | 0.00141 |
| **Weeds** | 3 | 403.284\* | 0.76003\* | 1463.92\* | 20.9601\* | 9721.67\* | 1518.54\* | 2776.11\* |
| **Location** | 3 | 0.15817\* | 0.04525\* | 1.28382\* | 0.2901\* | 2841\* | 1.12101\* | 7.76063\* |
| **Weeds×Location** | 9 | 0.0538\* | 0.03505\* | 0.17758\* | 0.08274\* | 618.889\* | 5.50332\* | 50.7013\* |
| **Error** | 15 | 2.53E-31 | 0.00001 | 1.21E-30 | 5.09E-32 | 1.77E-29 | 1.35E-29 | 2.00E-29 |
| **Grand Mean** | 5.03 | 0.5266 | 13.446 | 3.53 | 50.74 | 71.541 | 79.71 |
| **Standard Error** | 0.071 | 0.0573 | 0.129 | 0.0881 | 7.6171 | 0.7183 | 2.1802 |

\*= Significant at 5% probability level

**Table 2. Mean performance of weeds at various locations**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | **No of plant** |  |  |
| **Weeds/Locations** | **CEMB** | **Hanjerwal** | **Punjab University** | **Kasur** | **Average** |
| *Digeria arvensis* | 50.13b | 20.22b | 80.14b | 65.36b | 53.9625b |
| *Cyperus rotundus* | 40.28c | 15.17c | 50.29c | 34.55c | 35.0725c |
| *Digitaria adscendense* | 100.81a | 45.22a | 120.87a | 123.67a | 97.6425a |
| *Sorghum halepense* | 35.56d | 10.98d | 8.67d | 9.87d | 16.27d |
| **Average** | 56.695c | 22.8975d | 64.9925a | 58.3625b |  |
|  |  | **Fresh plant weight (g)** |  |
| **Weeds/Locations** | **CEMB** | **Hanjerwal** | **Punjab University** | **Kasur** | **Average** |
| *Digeria arvensis* | 9.807b | 9.417b | 8.773b | 9.113b | 9.278b |
| *Cyperus rotundus* | 6.373c | 6.150c | 5.450c | 6.410c | 6.096c |
| *Digitaria adscendense* | 4.920d | 4.097d | 4.373d | 4.740d | 4.533d |
| *Sorghum halepense* | 34.253a | 33.430a | 32.853a | 33.070a | 33.402a |
| **Average** | 13.838a | 13.273c | 12.863d | 13.333bc |  |
|  |  | **Fresh inflorescence weight (g)** |
| **Weeds/Locations** | **CEMB** | **Hanjerwal** | **Punjab University** | **Kasur** | **Average** |
| *Digeria arvensis* | 4.333ab | 4.367ab | 4.400ab | 4.667b | 4.442ab |
| *Cyperus rotundus* | 4.707a | 4.447a | 4.327a | 5.000a | 4.620a |
| *Digitaria adscendense* | 4.097abc | 3.457b | 3.487c | 3.743c | 3.696b |
| *Sorghum halepense* | 1.317b | 1.273c | 0.737d | 1.143d | 1.118c |
| **Average** | 3.613b | 3.386c | 3.238d | 3.638a |  |
|  |  | **Dry plant weight (g)** |  |
| **Weeds/Locations** | **CEMB** | **Hanjerwal** | **Punjab University** | **Kasur** | **Average** |
| *Digeria arvensis* | 1.643b | 1.367bc | 1.093c | 1.290d | 1.348c |
| *Cyperus rotundus* | 1.363cd | 1.340b | 1.337bc | 1.327c | 1.342c |
| *Digitaria adscendense* | 1.400c | 1.327bcd | 1.377b | 1.447b | 1.388b |
| *Sorghum halepense* | 15.977a | 15.610a | 15.207a | 15.440a | 15.558a |
| **Average** | 5.096a | 4.911b | 4.753d | 4.876c |  |
|  |  | **Dry inflorescence weight (g)** |  |
| **Weeds/Locations** | **CEMB** | **Hanjerwal** | **Punjab University** | **Kasur** | **Average** |
| *Digeria arvensis* | 0.710bc | 0.703a | 0.767a | 1.033a | 0.803a |
| *Cyperus rotundus* | 0.713b | 0.677b | 0.557b | 0.703b | 0.663b |
| *Digitaria adscendense* | 0.033d | 0.027d | 0.030d | 0.273d | 0.091d |
| *Sorghum halepense* | 0.717a | 0.620c | 0.343c | 0.410c | 0.523c |
| **Average** | 0.543a | 0.507c | 0.424d | 0.605a |  |
|  |  | **Total plant moisture percentage %)** |  |
| **Weeds/Locations** | **CEMB** | **Hanjerwal** | **Punjab University** | **Kasur** | **Average** |
| *Digeria arvensis* | 83.243a | 85.487a | 87.538a | 85.845a | 85.528a |
| *Cyperus rotundus* | 78.609b | 78.211b | 75.474b | 79.303b | 77.899b |
| *Digitaria adscendense* | 71.545c | 67.616c | 68.521c | 69.480c | 69.290c |
| *Sorghum halepense* | 53.357d | 53.305d | 53.713d | 53.311d | 53.422d |
| **Average** | 71.688b | 71.155d | 71.312c | 71.985a |  |
|  |  | **Total inflorescence moisture percentage (%)** |  |
| **Weeds/Locations** | **CEMB** | **Hanjerwal** | **Punjab University** | **Kasur** | **Average** |
| *Digeria arvensis* | 83.615c | 83.893c | 82.576c | 77.857c | 81.985c |
| *Cyperus rotundus* | 84.844b | 84.783b | 87.134b | 85.933b | 85.674b |
| *Digitaria adscendense* | 99.186a | 99.229a | 99.140a | 92.698a | 97.563a |
| *Sorghum halepense* | 45.570d | 51.309d | 53.394d | 64.140d | 53.603d |
| **Average** | 78.304c | 79.803b | 80.561a | 80.157ab |  |

**Table 3. Pooled correlation among various weed traits**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Traits** | **Dry plant** **weight** | **Inflorescence** **Dry weight** | **Fresh plant** **weight** | **Inflorescence** **Fresh weight** | **No of plants/m2** | **Total plant** **moisture** **percentage** |
| **Inflorescence Dry weight** | -0.0072 |  |  |  |  |  |
| **P<0.05** | 0.9688 |  |  |  |  |  |
| **Fresh plant weight** | 0.9888\* | -0.1261 |  |  |  |  |
| **P<0.05** | 0.000 | 0.4918 |  |  |  |  |
| **Inflorescence Fresh weight** | 0.9537\* | 0.2424\* | 0.9191\* |  |  |  |
| **P<0.05** | 0.0000 | 0.1813 | 0.0000 |  |  |  |
| **No of plants/m2** | 0.5417\* | \*0.4069\* | 0.5839\* | 0.3958\* |  |  |
| **P<0.05** | 0.0014 | 0.0208 | 0.0005 | 0.0249 |  |  |
| **Total plant moisture** **percentage** | 0.8731\* | 0.4238\* | 0.7929\* | 0.9347\* | 0.2839\* |  |
| **P<0.05** | 0.0000 | 0.0157 | 0.0000 | 0.0000 | 0.1153 |  |
| **Total inflorescence moisture percentage** | 0.9096\* | 0.3935\* | 0.9463\* | 0.7815\* | 0.6333\* | 0.6281\* |
| **P<0.05** | 0.0000 | 0.0259 | 0.0000 | 0.0000 | 0.0001 | 0.0001 |

1. **Conclusions**

It was concluded that the weed controlling measuring practices should be carried out to minimize the yield losing effects of weeds. The herbicide resistant crop varieties should be developed to control weeds.

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**References**

1. Ali Q, Ahsan M, Ali F, Aslam M, Khan NH, Munzoor M, Mustafa HSB, Muhammad S. 2013. Heritability, heterosis and heterobeltiosis studies for morphological traits of maize (Zea mays L.) seedlings. Adv. life sci., 1(1): 52-63.
2. Ali Q, Ali A, Ahsan M, Ali S, Khan NH, Muhammad S, Abbas HG, Nasir IA, Husnain T. 2014b. Line × Tester analysis for morpho-physiological traits of Zea mays L. seedlings. Adv. life sci., 1(4): 242-253.
3. Ali Q, Ali A, Awan MF, Tariq M, Ali S, Samiullah TR, Azam S, Din S, Ahmad M, Sharif NM, Muhammad S, Khan NH, Ahsan M, Nasir IA and Hussain T. 2014a. Combining ability analysis for various physiological, grain yield and quality traits of *Zea mays* L.*Life Sci J* 11(8s):540-551.
4. Cavaco A, 1954. *Amaranthacées* (*Amaranthaceae*). Flore de Madagascar et des Comores (plantes vasculaires), familles 66–69. Firmin-Didot et cie., Paris, France, pp:56.
5. David Q. 1998. "Planet of Weeds", Harper's Magazine, retrieved November 15, 2012
6. Elahi, M. Z.A. Cheema, S.M.A. Basra and Q. Ali**,** 2011a**.** Use of allelopathic extracts of sorghum, sunflower, rice and *Brassica* herbage for weed control in Wheat (*Triticum aestivum* L.). *IJAVMS****,*** 5: 488-496.
7. Elahi, M. Z.A. Cheema, S.M.A. Basra, M. Akram and Q. Ali**,** 2011b**.** Use of Allelopathic water extract of field crops for weed control in Wheat. Int. Res. J. Plant Sci., 2: 262-270.
8. Heatwole, H., Done, T., Cameron, E. 1981. Community Ecology of a Coral Cay, A Study of One-Tree Island, Great Barrier Reef, Australia. Series: Monographiae Biologicae, 43: 102.
9. Holm, L. G., P. Donald, J. V. Pancho, and J. P. Herberger. 1977. The World's Worst Weeds: Distribution and Biology. The University Press of Hawaii, Honolulu, Hawaii. Pp: 609.
10. Janick, J. 1979. Horticultural Science (3rd ed.). San Francisco: W.H. Freeman. p. 308. ISBN 0-7167-1031-5.
11. Martin, M.H., and J.R. Cox. 1984. Germination profiles of introduced lovegrasses at six constant temperatures. Journal of Range Management. 37(6):507-509.
12. Qamar, Z, Aaliya K, Nasir IA, Farooq AM, Tabassum B, Qurban A, Ali A, Awan MF,Tariq M and Husnain T.An overview of genetic transformation of glyphosate resistant gene in *Zea mays*. *Nat Sci*. 2015;13(3): 80-90.
13. Robert & POL Chanthy, 2009, Weeds of Upland Cambodia, ACIAR Monagraph 141, Canberra, [1].
14. Santos, B. M., J. P. Morales-Payan, W. M. Stall and T. A. Bewick (1998). Influence of purple nutsedge (*Cyperus rotundus*) density and nitrogen rate on radish (*Raphanus sativus*) yield. Weed Sci. 46: 661-664.
15. Seshadri S. and Nambiar V.S. 2003. Kanjero (Digera arvensis) and drumstick leaves (Moringa oleifera): nutrient profile and potential for human consumption. World Rev Nutr Diet. 91:41-59.
16. Shabana, Y. M., R. Charudattan, A. H. Abou-Tabl, J. P. Morales-Payan, E. N. Rosskopf and W. Klassen (2010). Production and application of the bioherbicide agent *Dactylaria higginsii* on organic solid substrates. Biol. Cont. 54: 159-165.
17. Steel, R.G.D., J.H. Torrie and D.A. Dickey. 1997. Principles and Procedures of Statistics: A biometrical approach. McGraw Hill Book Co. New York. USA. pp: 400-428.
18. Townsend CC, 1985. Amaranthaceae. In: Polhill, R.M. (Editor). Flora of Tropical East Africa. A.A. Balkema, Rotterdam, Netherlands, Pp: 136.
19. Townsend, CC, Amaranthaceae. In: Edwards, S, Mesfin Tadesse, Demissew Sebsebe & Hedberg, I. (Editors), Flora of Ethiopia and Eritrea. Volume 2, part 1. Magnoliaceae to Flacourtiaceae. The National Herbarium, Addis Ababa University, Addis Ababa, Ethiopia and Department of Systematic Botany, Uppsala University, Uppsala, Sweden, 2000, 299–335.
20. Travlos, I. S., G. Economou, V. E. Kotoulas, P. J. Kanatas, A. N. Kontogeorgos and A. I. Karamanos (2009). Potential effects of diurnally alternating temperatures and solarization on purple nutsedge (*Cyperus rotundus*) tuber sprouting. J. Arid Environ. 73: 22-25.

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