IMPACT OF WEEDS ON DIVERSITY OF SOIL ARTHROPODS IN *Bt* COTTON FIELD IN FAISALABAD PAKISTAN

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https://doi.org/10.28941/26-1(2020)-10

ABSTRACT

The present study was conducted to verify the impact of weeds on diversity of soil arthropods in Bt cotton field by using Randomize Complete Block Design with four treatments and three replications at the Research Area of Department of Entomology, University of Agriculture Faisalabad, Pakistan. Treatments consisted of different combinations of weeds and control group. Total 228 samples were collected and from these samples 14 different taxons of soil arthropods were reported and from these taxa, mites showed the highest diversity index. Maximum diversity of soil arthropods was recorded (H´=2.07) from Trianthema portulacastrum (horse purslane vern. Itsit) + *Echinochloa colona (Jungle rice vern Swanki) and minimum diversity of soil arthropods was recorded (H´=1.90) from T. portulacastrum + Amaranthus viridis (green amaranth vern. chulai) Maximum mean richness of soil arthropods (S=3.18±0.24) was reported from T. portulacastrum + Chenopodium murale, while minimum mean richness of soil arthropods (S=3±0.23) was reported from the Control group. Maximum mean abundance of soil arthropods (14.7±4.11) was reported from T. portulacastrum + Echinochloa colona while minimum mean abundance of soil arthropods (11.5±2.26) was reported from control group. The data showed that the plots which had weeds provided most favorable environment for soil arthropods and in turn enhanced the arthropods diversity. The maximum temperature was positively correlated with the diversity of soil arthropods. Further studies are suggested to confirm our findings.*

Keywords: Soil arthropods, *Bt* cotton, soil taxa, weed diversity.

Citation: Munir, I., A. Ghaffar, A. Aslam, M. K. Shahzad and M. Jafir. 2020. Impact of weeds on diversity of soil arthropods in *bt* cotton fields in Faisalabad Pakistan. Pak. J. Weed Sci. Res. 26 (1): 119-129.

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INTRODUCTION

American upland cotton *(Gossypium hirsutum* L.*)* is the most important fibre crop around the world. Cotton is the raw material for one of the world's leading textile industry in Pakistan. Textile industry worldwide has an economic impact of at least $600 billion yearly around the globe (Ashraf *et al*., 2018). Agriculture sector is an important component of economy roughly with share of 19% in Gross Domestic Product, in Pakistan. Meanwhile, agriculture sector has a reduced capabilities as compared to its potential, due to different bottlenecks. On the other hand, there is a clear decline in share of agriculture sector in GDP as time passes. Being a source of raw material in textile industry, cotton is the most important crop of Pakistan termed as the silver fibre of the country and serves as cash crop of Pakistan. Cotton contributes 5.2% of value addition in agriculture and 1% of Gross Domestic Product (GOP, 2017).

Weeds refer to unwanted plants growing within or external to crop, due to which crop production is reduced resulting in complete crop loss if not controlled (Norris and Kogan, 2000). Weeds are symbolized as a source of vegetative biodiversity, as they vie with main crops for minerals, water and sunlight as well (Altieri, 1999). In organic and conventional agro-ecosystems there exists association among weeds and diversity of arthropods (Hadjicharalambous *et al.,* 2001).

In agricultural systems, there exists strong association among weeds and soil arthropods. Weeds perform obliquely in supplying nutrients and protection to their omnivorous arthropods. They also provide nutrient rich environment to arthropods which are herbivorous in nature (Norris and Kogan, 2005). Inside the food web, weeds are ultimate source of food for useful arthropods. Arthropods which utilize weeds as a food source become the food of first order omnivorous arthropods (Noranjo and Sitmac, 1987).

Soil encompasses a huge diversity of minute invertebrates like nematodes, mites and spring tails that change their distribution in space and time (Bardgett, 2002). Ecosystem engineers, chemical engineers and biological organizers are three main divisions of soil arthropods. Species which act as soil chemical engineers like that of fungi, protozoa and bacteria are responsible for degradation of plant materials into nutrients for the sake of humans, plants and animals as well (Gardi and Jeffrey, 2009). Invertebrates perform important actions in soils. Invertebrates have many actions that are modified within soil, as soil serves as host for extremely dispersed invertebrates population. Soil invertebrates depend upon vastly on microorganisms, need to draw out assemblages of organic sources of soil (Lavelle, 1997). Alteration in plant fragments is the key role played by arthropods through decaying. The inward movement of particles and liquid, rise in water holding capability, flush out cell constituents, damaged leaf covering and aeration is done by substantial crumbling (Zimmer, 2002).

Soil organisms contribute in many functions and soil processes. These are important components of agro-ecosystem. In the absence of soil organisms crop yield is not sustained and soil is infertile medium. Essential soil processes are carried out by these organisms, thus enhancing the crop productivity via increased soil fertility. Soil organisms ease out the release of nutrients through decomposition processes (Lavelle *et al.,* 2006). Alteration in soil environments plays a significant role in enhancing abundance and dynamics, community structure in agricultural management practices. These arthropods change soil type, taxonomic groups, and climate, land and ecosystem interactions with cropping system (Roy *et al*. 2018). Soil micro arthropods such as collembolan and mites are indicators for broadcasting persistent natural and agricultural systems through their characteristics such as high density, specie richness and ecological significance (Motohiro, 2001). Hence, the present study was undertaken to decipher the correlation of different weed species with the diversity of arthropods in *bt* cotton crop.

MATERIALS AND METHODS

The present study was conducted to evaluate the effect of weeds on the diversity of soil arthropods at the research area of the Department of Entomology, University of Agriculture Faisalabad, Pakistan in randomized complete block design having three replications and four treatments as under:

T1= *Trianthema portulacastrum* (horse purslane vern. Itsit + *Digera muricata* (False amaranth vern. Tandla).

T2= *Trianthma portulacastrum* (horse purslane vern. Itsit) + *Echinchloa colona* (jungle rice vern. Sawanki).

T3= *Trianthma portulacastrum* (horse purslane vern. itsit) + *Amaranthus viridis* green amaranth vern. Chulai).

T4=Control (weed free).

After the land preparation, cotton seeds were sown manually. Sowing was done on 10th of May, 2018. The distance between plants was 30 cm, while distance between the rows was kept at 45 cm. After that three weeds combinations were sown in the field, while the fourth group was weed free as a check. Uniform agronomic practices were provided to all the experimental plots. Data were recorded at weekly interval starting from 1st week of July till the end of November to record the weekly change in the population of arthropods. With the help of soil core sampler the soil sampling was done for the extraction and collection of soil arthropods. The size of every soil sample taken was equal to 12 x 10.5 cm which was the size of the core of the sampling tool. The soil sample was pressed beneath the plant canopy till a depth of 15 cm. The collected soil samples were transferred into polythene bags and were tagged properly. The samples were then brought to the Laboratory for the extraction of soil arthropods.

The extraction of every kind of arthropods was done by using modified tullgern funnel for 48 hours under light source (Hopkins, 2000). The extracted soil arthropods were identified with the help of different taxonomic keys. After identification, the specimens were shifted into vials containing 75% ethyl alcohol in order to preserve them. Total sum of diversity of soil arthropods were checked out by using Shannon diversity index (Shannon, 1948). Chao 1 diversity index for soil arthropods was also calculated to evaluate the richness of soil arthropods and to figure out the no of missing taxons due to sampling methods (Colwell *et al.,* 2012). Fisher alpha diversity was also calculated for each weed combination (Taylor, 1978).

Weather Data

Data of different weather factors including rainfall, maximum temperature, minimum temperature, relative humidity was obtained from Crop Physiology Department, University of Agriculture Faisalabad, Pakistan. Data were arranged monthly and averages were computed for each parameter for correlation analysis of abiotic factors with soil arthropods abundance and to calculate the effect of each parameter on the abundance and richness of soil arthropods.

RESULTS

1. Taxon wise Shannon's diversity index of soil arthropods

Total 228 samples were collected during the whole experimental duration from all replications. Diversity index of different taxons were performed. Statistical analysis of the data showed that maximum diversity was represented by mites (2.50%) followed by beetles, adult stage (2.46%) and then ants with values (2.36%). The minimum diversity indices were represented by termites (0.89%), sun scorpion (0.49%) and scorpion (0.34%). While, the remaining were between maximum and minimum values such as spider (1.42%), centipedes (1.48%), pill bug (1.60%), moth (1.77%), dipteran flies (1.88%), fly, adult stage (1.95%), millipedes (2.14%), symphyla (2.15%) and proturans (2.17%), respectively (Table-1).

2. Date wise diversity index of soil arthropods

Results of date wise diversity indices showed that maximum diversity was showed at 17th Oct (1.98), 26th Sep (1.86) and 29th Aug (1.85). Minimum diversity indices were at 3rd Oct (0.87) and 10th Oct (0.98). The others were between the maximum and minimum values 1st Aug (1.29), 8th Aug (1.39), 22nd Aug (1.42),15th Aug (1.45),19th Sep (1.49),4th July(1.61),12th Sep (1.66),18th July (1.73) and 5th Sep (1.77) (Table-2).

3. Shannon diversity and Fisher's alpha index of soil arthropods

The Shannon diversity on an average for soil arthropods from all three replications was studied and statistical results were described in (Table 3) showed that the maximum Shannon diversity index value (H'=2.07) was recorded for *T. portulacastrum+ Echinochloa colona*. Minimum Shannon diversity index value (H'=1.90) was reported for *T. portulacastrum + Chenopodium murale (*Table-3).

The Fisher's Alpha diversity index of soil arthropods from all replications were analysed statistically and results showed that Fisher's Alpha diversity values were statistically different between different weed combinations and maximum values was recorded as 2.93 for *T. portulacastrum + Chenopodium murale* followed by *T. portulacastrum +Digera muricata* with Fisher's Alpha diversity values of 2.87 and 2.84 value was reported for *T. portulacastrum + Echinochloa colona*. The minimum Fisher's Alpha diversity value 2.77 was recorded for Control (Table-3).

4. Chao1 diversity index of Soil Arthropods

Chao1 diversity index of soil arthropods was computed and the statistical results showed that chao1 diversity value for all weed combinations were the same (chao1=16). This data showed that value of chao1 estimator and observed were the same and showed the maximum diversity of soil arthropods from all weed combinations (Table-4.).

Data of richness of soil arthropods from different weeds combinations showed non significant differences (F_{value}=0.961; P≤0.545) and maximum richness (3.18±0.24) of soil arthropods was found from *T. portulacastrum+Chenopodium murale*. Maximum richness (S=4.5±0.49) was recorded during July and minimum richness (S=1.62±0.30) was reported during October. Data of abundance of soil arthropods from different weed combinations also showed non- significant differences (F_{value}=0.186; P≤0.778) and maximum richness (14.7±4.11) of soil arthropods was for *T. portulacastrum + Echinochloa colona*. Maximum abundance (S=25.25±6.48) was recorded during September and minimum abundance(S=2.69±0.68) was reported during October, 2018.

Table-1. Taxon wise Shannon's diversity index of soil arthropods.

Species	Diversity index (%)
Spring tail	2.18
Beetles	2.46
Centipedes	1.48
Scorpion	0.34
Flies	1.95
Pill.bug	1.60
Ants	2.36
Sun.scorpion	0.49
Dipteran flies	1.88
Spider	1.42
Moth	1.77
Mites	2.50
Proturans	2.17
Termites	0.89
Sympyhla	2.15
Millipedes	2.14

Table 2. Date wise diversity index of soil arthropods

Date	Diversity index	Date	Diversity index
4-July	1.61	29-Aug	1.85
11-July	1.51	5-Sep	1.77
18-July	1.73	12 –Sep	1.66
1-Aug	1.29	19-Sep	1.49
8-Aug	1.39	26-Sep	1.86
15-Aug	1.45	3-Oct	0.87
22-Aug	1.42	10-Oct	0.98
		17-Oct	1.98

Table-3. Shannon diversity and Fisher's alpha index of soil arthropods.

Treatment	Shannon's diversity	Fisher's Alpha
T1. *T. portulacastrum + C. murale*	1.90	2.93
T2. *T. portulacastrum + D. muricata*	1.92	2.87
T3.*T. portulacastrum + E. colona*	2.07	2.84
T4. Control Group	1.92	2.77

Table- 4. Chao1 diversity index of Soil Arthropods.

Treatments	S. obs.	S.chao1	se.chao1
T. portulacastrum+ C. murale	16	16	0
T. portulacastrum + E. colona	16	16	0
T. portulacastrum + D. muricata	16	16	0.24

5. REGRESSION MODELS REPRESENTING DIFFERENT EFFECTS ON THE RICHNESS AND ABUNDANCE OF SOIL ARTHROPODS.

5.1 Richness of soil arthropods

For this analysis different kinds of regression models were prepared by the usage of abiotic factor data and richness data of soil arthropods of different weed combinations to estimate the input of these weather factors for the richness of soil arthropods from different weed combinations (Table 5.1). Model showed that minimum temperature alone contribute for richness of soil arthropods 4% while minimum temperature along with maximum temperature contribute 6%. Effect of three factors minimum temperature, maximum temperature and relative humidity was recorded 7% and combined effect of four abiotic factors 9% for richness of Soil Artropods. Results also showed that the final regression model: y= 14.237 – 0.318 X1 + 0.275 X2 - 0.1002 X3 + 0.095 X4 was the best model to describe these data regarding the richness of Soil Arthropods of different weed combinations.

Table 5.1 Regression models showing effect of different abiotic factors for the richness of soil arthropods

	Intercept					R^2
y=	-0.190	0.091X1				0.04
y=	4.123	-0.155X1	0.183X2			0.06
y=	13.432	-0.385X1	0.338X2	-0.073X3		0.07
y=	14.237	-0.318X1	0.275X2	-0.100X3	0.095X4	0.09

Where

Y= Richness of Soil arthropods — R^2= Coefficient of determination

X1= Minimum Temperature — X2= Maximum Temperature

X3= Rain fall — X4= Relative humidity

5.2. Abundance of soil arthropods

For this analysis different types of regression models were developed by using abiotic factor data and abundance data of soil arthropods of weed combinations to evaluate the role of these weather factors for the abundance of soil arthropods of different weed combinations (Table 5.2). Model showed that minimum temperature alone contribute for abundance of soil arthropods 0% while minimum temperature along with maximum temperature contribute 0%. Effect of three factors rainfall, minimum temperature and maximum temperature was recorded 0% and combined effect of four abiotic factors 0% for abundance of soil arthropods. Results also showed that the final multivariate regression model :y= -11.734 +1.4219X1-1.0137 X2 – 0.0301 X3 + 0.3162 X4 was the best abundance model to describe these data regarding the soil arthropods abundance.

Table 5.2 Regression models showing effect of different abiotic factors for the abundance of soil arthropods.

	Intercept					R^2
y=	9.293	0.104X1				0.00
y=	-6.592	1.009X1	-0.675X2			0.00
y=	-14.401	1.202X1	-0.805X2	0.061X3		0.00
y=	-11.734	1.422X1	-1.014X2	-0.030X3	0.316X4	0.00

Where

Y= Abundance of Soil arthropods

R^2= Coefficient of determination

X1= Minimum Temperature

X2= Maximum Temperature

X3= Rain fall

X4= Relative humidity

6. Principal Component Analysis about environmental variations and richness and abundance of soil arthropods

The data graph represented the interactions among different abiotic factors and their effect on soil arthropods richness and abundance. The graph 6 exhibited that richness was greatly affected by maximum temperature. Richness was also affected by minimum temperature to some extent. While the rain fall had greater impact on richness as compared to and relative humidity as it had no effect on richness of soil arthropods. While the abundance of soil arthropods was positively correlated with abundance of soil arthropods while remained unaffected by all abiotic factors as they were distant apart (Fig. 1).

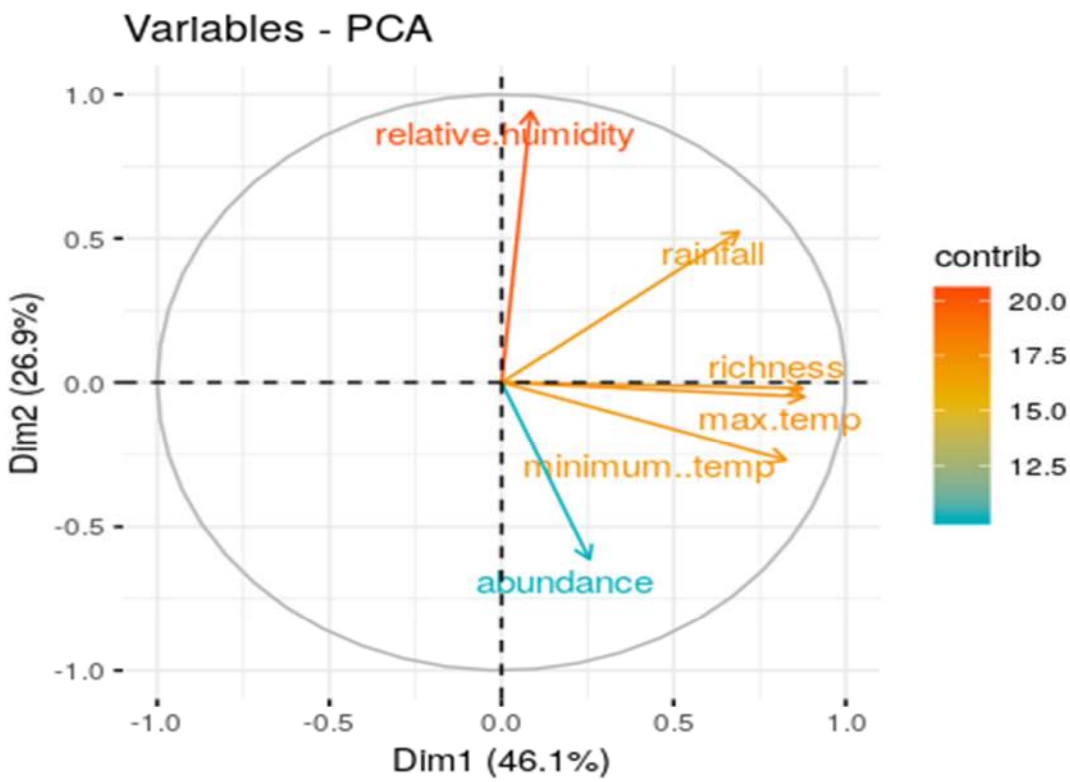

Fig. 1. Principal Component Analysis for variations, richness and abundance of soil arthropods.

DISCUSSION

A total of 14 different taxons (Spring tails, Beetles, Centipedes, Scorpion, Flies, Pill bug, Ants, Sun scorpion, Dipteran flies, Spiders, Moths, Mites, Termites, Symphyla, Millipedes and proturans) were collected from all three replications during the whole experimental period. The findings of this research revealed that weed presences enhanced the arthropods diversity because they provide nutrients and shelter for sol arthropods.

Chao1 diversity index of soil arthropods from four different treatments showed that chao1 diversity index value for all the four treatments of study area were the same (chao1=16) which showed that there is no difference of soil arthropods richness between the observed and calculated choa1 .

Fisher's Alpha diversity values varied among different treatments with maximum value (2.93) from *T. portulacastrum* + *C. murale* followed by *T. portulacastrum* + *D. muricata* (2.87) while minimum (2.77) was recorded from Control group. These results agreed with other findings (Altieri *et al*., 1985; Wardle, 1995) who reported that arthropod densities are often greater in weedy than weed-free environments, because weeds provides nutrients, and shelter to soil arthropods even if the main crop is not present , weeds served as alternative host for soil arthropods.

Maximum Shannon diversity index for soil arthropods was observed for *T. portulacastrum* + *E. colonai* with Shannon's diversity index value (H′=2.07) while minimum Shannon diversity index was observed for *T. portulacastrum* + *C. murale* with Shannon's diversity index (H′=1.90) confirmed with other findings likewise soil arthropods can be affected through plants and weeds (De Deyn *et al*., 2004; Bennett, 2010)

The data further showed that the richness and abundance of soil arthropods were non significant statistically exhibiting that the performance of all the treatments studied was the same. Our findings are are agreement with others (Stebaeva, 1963; Blackith, 1974) that the allocation and large quantity of collembolan species showed to be correlated to a obvious extent to plant species distinctiveness and divisionss.

Weeds played a role in increasing arthropods diversity because they served as a food sources even in the absence of any crop so in this way they enhanced the diversity of soil arthropods which confirmed our result with other findings like (Blackith, 1974) that soil arthropods were forced to live in closer association with weeds for food resources.

Statistically analyzed data showed that abundance of soil arthropods were the same for all combinations of weeds showed they provided nutrients to soil arthropods for their survival. These findings are in line with Norris and Kogan (2005) who reported that weeds raced to plants for nutrient requirements and modified the physical surroundings and supplied protection and food for arthropods.

CONCLUSION

It is concluded that all weed combinations had almost same diversity of soil arthropods. The plots which had weeds in different combinations were equally effective for encompassing different kinds of soil arthropods, while the weed free plots had very few number of soil arthropods. Correlation of different abiotic factors with richness of soil arthropods showed that maximum temperature was positively correlated with soil arthropods.

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