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# Studies on shifts in weed flora in maize (*Zea mays* L.) in Kangra district of Himachal Pradesh

Surinder Singh Rana *, Rahul Sharma, Akashdeep Singh, Suresh Kumar

*Department of Agronomy, Forages and Grassland Management COA, CSK Himachal Pradesh Krishi Vishwavidyalaya, Palampur 176 062, HP, India*

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**ABSTRACT**

Over centuries, agricultural practices have undergone the transition from extensive and traditional to intensive and specialized. Thus, the weeds colonizing cultivated fields are subjected to major shifts due to increased use of herbicides, fertilizers and tillage. There are a total of 176 weed species in Agro-ecosystems of Himachal Pradesh and not less than 46 in maize. Weeds, in maize, are hardier in nature and compete with the crop significantly reducing its yield. Also, slow initial growth and wider spacing favour the growth of weeds even before crop emergence. *Commelina benghalensis, Ageratum conyzoides, Echinochloa colona, Panicum dichotomiflorum, Cyperus iria, Digitaria sanguinalis, Polygonum alatum and Aeschynomene indica* were dominant weeds observed under Kangra district conditions of Himachal Pradesh. The phytosociological study showed that the species which invaded the non-cropped lands are increasingly infesting the cultivated fields. In 2008, most abundant weed was *Fimbristylis miliacea* followed by *Cyperus difformis*, *Eragostis tennela*, *Ageratum conyzoides*, *Ammannia baciferra*, *Bidens pilosa* and *Hackelia uncinata*. In 2018, *Ageratum conyzoides* was the most abundant followed by *Phyllanthus niruri, Panicum dichotomiflorum,* and *Commelina benghalensis. Ageratum conyzoides* was the most important weed in 2008 followed by *Echinochloa colona*, *Fimbristylis miliacea*, and *Digitaria sanguinalis*, in that order. The Important Value Index (IVI) for individual weed species in the maize field crop in 2018 indicated that *Ageratum conyzoides* was again the most important weed species followed by *Phyllanthus niruri*, *Echinochloa colona, Alternanthera philoxeroides, Aeschynomene indica*, *Commelina benghalensis* and *Digitaria sanguinalis*. The weed species *viz. Ammannia baccifera, Bidens pilosa, Brachiaria ramose, B. reptans, Dactyloctenium aegyptium, Fimbristylis miliaceaum, Galinsoga parviflora, Hackelia uncinata, Ipomoea pestgridis, and Physalis minima* those recorded in 2008 were not found in the survey of 2018. *Aeschynomene indica, Alternanthera philoxeroides, Amaranthus viridis, Echinochloa crusgalli and Oxalis sp.* recorded during 2018 were not found in the survey of 2008.

Corresponding author, email: ranassdee@gmail.com (Surinder Singh Rana).

## Introduction

A Weed Shift refers to a change in the relative abundance, density, frequency or types of weeds as a result of management practice. The management practice could be any of the cultural, mechanical, chemical or biological that brings about change in weed species composition (Subbulakshmi et al. 2009; Pradeep et al. 2017). It may also be due to the natural environmental changes in an agricultural system. The weeds susceptible to a herbicide, used repeatedly, are eliminated over time leaving tolerant weed species, which often thrive with reduced competition. There is a gradual increase in tolerant weed species (Tuesca et al. 2001; Suresha, 2014). So, this is the failure of the weed management practices that do not control an entire weed community or population. These shifts are likely to occur in the agricultural production system that suggests changes in weed flora must be monitored continuously in all cropping systems and Agro-ecological regions (Suresha, 2014; Tuescaet al. 2001) in order to assess emerging weed problems and plan weed management strategies accordingly. Effective weed management practices begin with proper identification to assess the competitiveness of the weeds present and to select the proper herbicide if one is needed (Subbulakshmi et al. 2009; Pradeep et al. 2017; Waheed Ullah et al. 2008). A weed management strategy to prevent weed shifts and weed resistance requires knowledge of the composition of weeds present (Orloff et al. 2008). Therefore, a survey was conducted in the year 2008 and again after a period of 10 years to monitor the change in the weed flora in the agricultural system.

## Materials and Methods

Kangra district covers three agro-climatic zones *viz*. Zone-1- Submontane low hills (350-650 m AMSL) comprising Nurpur, Rehan, Fatehpur, Jawali etc.; Zone II- Mid hill subhumid zone (651-1800 m AMSL) comprising Palampur, Dadh, Nagrota Bagwan etc. and Zone III- High hills wet temperate zone ( 1800-2000 m AMSL) comprising Tholtu, Baragram, Kothi Kodh and Barot. The soils of this district are slightly acidic to neutral in reaction and sandy loam to silty clay loam in texture. The important crop rotations of the district were maize-wheat, rice-wheat, frenchbean/urdbean-wheat/barley and maize-potato. Weed survey of maize crops of Kangra district was conducted during *kharif* 2008 along following six routes by using GPS and quadrate at every 5-10 km (Table 1).

**Table 1**. Coordinates of the major routes of kharif 2008 survey.

| Route | Altitude | Latitude | Longitude |
|---|---|---|---|
| Palampour-Shantinagar-Jaisinghpur-Thural | 595-982 | 31° 51' 1.9"<br>32° 2' 38.6" | 76° 30' 15.8"<br>76° 32' 2.0" |
| Naltipul-Kural-Dhaliara-Dhadasiba | 340-850 | 31° 56' 39.6"<br>32° 02' 3.1" | 75° 55' 38.1"<br>76° 27' 44.7" |
| Rehan-Fatehpur-Kathgarh-Indora-Jwali-Harsar | 269-532 | 32° 7' 6.9"<br>32° 15' 31.9" | 75° 38' 11.6"<br>75° 52' 4.9" |
| Nagrota Surian-Masroor-Tiyara-Matour-Nagrota Bagwan-Bhatu | 493-1063 | 32° 4' 5.1"<br>32° 5' 4.2" | 76° 6' 15.2"<br>76° 29' 40.2" |
| Thultu-Baragram-Kothikodh-Barot-Sungal | 1168-2350 | 32° 04' 58.4"<br>32° 4' 52.1" | 76 35' 20.1"<br>76 45' 52.4" |
| Chimbalhar-Bagoda-Dadh-Tangroti | 1010-1197 | 32° 9' 13.7"<br>32° 07' 24.8" | 76° 22' 27"<br>76° 29' 6.7" |

The district was again surveyed after a period of ten years during 2018. Survey during 2008 represents whole of the district while that during 2018 a part of the district. Survey of 2018 represents the areas lying between Palampur and Kangra during the *Kharif* season in the farmers' field with Maize as their crop. The important quantitative analysis such as density, frequency, and abundance of weed species, was done as per Curtis and McIntosh (1950).

$$Density = \frac{Total\ number\ of\ individuals\ of\ a\ species\ in\ all\ quadrats}{Total\ number\ of\ quadrats\ studied}$$

$$Frequency\ (\%) = \frac{Total\ number\ of\ quadrats\ in\ which\ the\ species\ occurred}{Total\ number\ of\ quadrats\ studied}\ x\ 100$$

$$Abundance = \frac{Total\ number\ of\ individuals\ of\ a\ species\ in\ all\ quadrats}{Total\ number\ of\ quadrats\ in\ which\ the\ species\ occurred}$$

$$Relative\ density = \frac{Total\ number\ of\ individuals\ of\ a\ species}{Number\ of\ individuals\ of\ all\ the\ species}\ x\ 100$$

$$Relative\ frequency = \frac{Total\ number\ of\ occurrence\ of\ the\ species}{Number\ of\ occurrence\ of\ all\ the\ species}\ x\ 100$$

$$Relative\ abundance = \frac{Total\ number\ of\ individuals\ of\ a\ species\ in\ all\ quadrats}{Total\ number\ of\ individuals\ of\ all\ species\ in\ all\ quadrats}\ x\ 100$$

Importance Value Index (IVI): In calculating this index, the percentage values of the relative frequency, relative density and relative abundance are summed up together and this value is designated as the Importance Value Index or IVI of the species (Curtis, 1959). As IVI is a value out of 300, summed dominance is obtained by dividing IVI with 3 to have representation in the 100% scale.

**Results and Discussion**

Phytosociological analysis of surveys of weed flora in maize conducted during 2008 (Table 3) and 2018 (Table 4) revealed more than twenty three weed species in 2008 and a total of 16 weed species in 2018 from the 40 randomly thrown quadrats in each survey. But before analysing the results of these surveys it is thought to have insight of previous studies highlighting the maize – weed associations (Table 2). The historical analysis and highlights revealed that there are 176 confirmed weed species so far in the Agro-ecosystems of Himachal Pradesh (Rana et al. 2018a). In maize total weeds associated were not less than 46 as is indicated from the Table 2. Rana et al. (1998) reported *Dactyloctenium aegyptium*, *Digitaria sanguinalis*, *Eleusine indica*, *Cyperus rotundus*, *Amaranthus viridis*, *Commelina banghalensis*, *Corchorus acutangulus*, *Euphorbia glomifera*, *Ipomoea hederacea*, *Mullugo stweta*, *Portulaca oleracea*, *Solanum nigrum* and *Veronica persica* the important weed associations in maize in the Kullu valley of Himachal Pradesh. Weed flora in maize at Palampur was mainly composed of *Commelina benghalensis* (25.6 and 12.3% at 60 DAS and at harvest, respectively), *Ageratum conyzoides* (45.1 and 56.1%), *Echinochloa colona* (L.) Link (17.6% and 8.7%), *Panicum dichotomiflorum* (8.4 and 7.7%), *Cyperus iria* (2.8 and 7.2%), *Digitaria sanguinalis* (0.0 and 8.2%) and *Polygonum alatum* (0.5 and 8.0%) and *Aeschynomene indica* showed its sporadic occurrence (Kumar et al. 2012).

Shivani Chand et al. (2016) found that *Echinochloa colona* and *Commelina benghalensis* were the major weeds constituting 22.6 and 20.7 per cent, respectively, of total weed population. *Ageratum conyzoides*, *Cyperus* sp., *Digitaria sanguinalis* and *Panicum dichotomiflorum* constituted 16.0, 14.1, 14.5 and 12.2 per cent, respectively, of total weed population. Kumar et al. (2017) found *Echinochloa colona*, *Cyperus iria*, *Equisetum arvense*, *Setaria glauca*, *Paspalum* sp, *Ageratum conyzoides* and *Bidens pilosa*, as the major weeds in maize at Kangra. Rana et al. (2018b) reported that major weeds at the harvest of maize were *Echinochloa colona* (22.6 and 29.0% during 2014 and 2015, respectively), *Commelina benghalensis* (19.4 and 19%), *Polygonum alatum* (24.2 and 18.3%) and *Ageratum conyzoides* (29.0 and 27.9%) at Palampur. *Ageratum conyzoides* was appeared at silking stage of maize. The other weeds *viz*. *Cynodon dactylon*, *Brachiaria ramose*, *Panicum dichotomiflorum*, *Galinsoga parviflora* and *Phasalis minima* showed their little infestation and as a whole constituted 4.8 and 5.8% of the total weed flora in the unweeded check.

**Table 2.** Chronological perspective of maize – weed association in Kangra district.

| Weed species | 1992 | 2009-2010 | 2009-2010 | 2012-2013 | 2013 | 2012-2013 | 2014-2015 | 2008 | 2018 |
|---|---|---|---|---|---|---|---|---|---|
| | Rana et al. (1998) | Kumar et al 2012 | Ramesh et al (2014) | Suresha (2014) | Sivani Chand et al (2016) | Kumar et al. (2017) | Rana et al (2018b) | Present survey 2008 | Present survey 2018 |
| *Aeschynomene indica* | | | | | | | | | x |
| *Ageratum conyzoides* | | x | x | x | x | x | x | x | x |
| *Ageratum houstonianum* | | | | x | | | | | |
| *Alternanthera philoxeroides* | | | | | | | | | x |
| *Amaranthus viridis* | x | | | | | | | | x |
| *Ammannia baccifera* | | | | | | | | x | |
| *Bidens pilosa* | | | | x | | x | | | |
| *Brachiaria ramose* | | | | | | | x | x | |
| *Brachiaria reptans* | | | | | | | | x | |
| *Commelina banghalensis* | x | x | x | x | x | | x | x | x |
| *Commelina forskalli* | | | | | | | | x | |
| *Corchorus acutangulus* | x | | | | | | | | |
| *Cynodon dactylon* | | | | x | | | x | | |
| *Cyperus diffromis* | | | | | | | | x | |
| *Cyperus iria* | | x | | x | | x | | x | |
| *Cyperus rotundus* | x | | | | | | | | |
| *Cyperus sp* | | | | x | x | | | | x |
| *Dactyloctenium aegyptium* | x | | | | | | | x | |
| *Digitariasanguinalis* | x | x | x | | x | | | x | x |
| *Echinochloa colona* | | x | x | | x | x | x | x | x |
| *Echinochloa crusgalli* | | | | x | | | | | x |
| *Echinochloa sp* | | | | x | | | | | |
| *Eleusine indica* | x | | x | | | | | x | |
| *Equisetum arevense* | | | | | | x | | | |
| *Eragrostis tennela* | | | | | | | | x | |
| *Euphorbia glomifera* | x | | | | | | | | |
| *Fimbristylis miliaceum* | | | | | | | | x | |
| *Galinsoga parviflora* | | | | x | | | x | x | |
| *Hackalia uncinata* | | | | | | | | x | |
| *Ipomoea hederacea* | x | | | | | | | | |
| *Ipomoea pestigridis* | | | | | | | | x | |
| *Mullugo stweta* | x | | | | | | | | |
| *Oxalis sp* | | | | | | | | | x |
| *Panicum dichotomiflorum* | | x | x | | x | | x | x | x |
| *Paspalum sp* | | | | | x | | | | |
| *Phasalis minima* | | | | | | | x | x | |
| *Phyllanthus niruri* | | | | | | | | x | x |
| *Polygonum sp* | | | | x | | | | | |
| *Polygonum alatum* | | x | x | | | | x | x | x |
| *Portulaca oleracea* | x | | | | | | | | |
| *Sesbania sp* | | | | x | | | | | |
| *Setaria glauca* | | | | | x | | | x | |
| *Setaria virisis* | | | | | | | | | x |
| *Solanum nigrum* | x | | | | | | | | |
| *Veronica persica* | x | | | | | | | | |

x, presence of a species

Ramesh et al. (2014) found that weed flora in maize crop was mainly composed of *Ageratum conyzoides* L. (57 and 70%, respectively at 60 and 90 DAS), *Polygonum alatum* L. (19 and 10%, respectively) and *Commelina benghalensis* L. (7 and 6%, respectively). The other weeds (*Echinochloa colona* (L.) Link, *Panicum dichotomiflorum* L., *Eleusine indica* L., *Digitaria sanguinalis* L. and *Cyperus sp*.) as a whole constituted 17 and 14%, respectively, at 60 and 90 DAS. Chopra and Angiras (2010) have also reported the association of these weeds with maize crop. Suresha (2014) indicated that in maize based cropping systems during *kharif*, *Commelina benghalensis* was the most dominant weed with infestation to the tune of 56 and 41% during 2012 and 2013, respectively.

*Density*

Density is an expression of the numerical strength of a species where the total number of individuals of each species in all the quadrates is divided by the total number of quadrates studied. Relative density is the study of numerical strength of a species in relation to the total number of individuals of all the species. Density of *Ageratum conyzoides* was highest amongst the maize weeds both during 2008 and 2018 with RD value of 13.9 and 65%, respectively. In maize, *Ageratum conyzoides* appears late in the season (Kumar et al. 2012) by the end of July or beginning of August. The large proportion of the weed in the later survey was probably due to decrease in the density of other weeds owing to adoption of herbicide technology in maize especially atrazine which was earlier limited to the extent of less than 10% (Singh et al. 1998) in 1996, 40-50% during 2007-08 and now increased to 75-80%. *Echinochloa colona*, *Digitaria sanguinalis*, *Cyperus iria*, *Commelina banghalensis*, *Brachiaria ramose* and *Panicum dichotomiflorum* followed *Ageratum conyzoides* during 2008 while *Phylanthus niruri*, *Alternanthera philoxeroides*, *Echinochloa colona*, *Aeschynomene indica* and *Commelina benghalensis* during 2018.

*Frequency (%)*

Frequency is the degree of dispersion of individual species in an area and usually expressed in terms of per cent occurrence. It was studied by sampling the study area at several places at random and recorded the name of the species that occurred in each sampling units. The degree of dispersion of individual species in an area in relation to the number of all the species occurred is termed as relative frequency. *Brachiaria ramose* was most frequently occurring weed in 2008 followed by *Echinochloa colona*, *Commelina benghalensis*, *Digitaria sanguinalis*, *Cyperus iria*, *Ageratum conyzoides*, *Eleusine indica*, *Commelina forskalli* and *Panicum dichotomiflorum*. In 2018, *Ageratum conyzoides* had highest frequency followed by *Echinochloa colona*, *Alternanthera philoxeroides*, *Digitaria sanguinalis*, *Aeschynomene indica*, *Phyllanthus niruri* and *Commelina benghalensis*.

**Table 3.** Phytosociology of weeds in maize in Kangra district of Himachal Pradesh during 2008 (Total quadrats, TQ= 40).

| Weed species | TOI | TNI | F | A | D | RF(%) | RA(%) | RD(%) | IVI | SDR |
|---|---|---|---|---|---|---|---|---|---|---|
| *Ageratum conyzoides* | 21 | 2074 | 52.5 | 99 | 51.9 | 7.0 | 4.9 | 13.9 | 25.8 | 8.6 |
| *Ammannia baccifera* | 2 | 192 | 5.0 | 96 | 4.8 | 0.7 | 4.7 | 1.3 | 6.7 | 2.2 |
| *Bidenspilosa* | 1 | 96 | 2.5 | 96 | 2.4 | 0.3 | 4.7 | 0.6 | 5.7 | 1.9 |
| *Brachiaria ramose* | 37 | 833 | 92.5 | 23 | 20.8 | 12.3 | 1.1 | 5.6 | 19.0 | 6.3 |
| *Brachiaria reptans* | 2 | 114 | 5.0 | 57 | 2.9 | 0.7 | 2.8 | 0.8 | 4.2 | 1.4 |
| *Commelina forskalii* | 16 | 586 | 40.0 | 37 | 14.7 | 5.3 | 1.8 | 3.9 | 11.1 | 3.7 |
| *Commelina benghalensis* | 32 | 952 | 80.0 | 30 | 23.8 | 10.6 | 1.5 | 6.4 | 18.5 | 6.2 |
| *Cyperus diformis* | 1 | 280 | 2.5 | 280 | 7.0 | 0.3 | 13.8 | 1.9 | 16.1 | 5.4 |
| *Cyperus iria* | 27 | 1142 | 67.5 | 42 | 28.6 | 9.0 | 2.1 | 7.7 | 18.7 | 6.2 |
| *Dactyloctenuim aegyptium* | 12 | 664 | 30.0 | 55 | 16.6 | 4.0 | 2.7 | 4.5 | 11.2 | 3.7 |
| *Digitaria sanguinalis* | 30 | 1322 | 75.0 | 44 | 33.1 | 10.0 | 2.2 | 8.9 | 21.0 | 7.0 |
| *Echinochloa colona* | 36 | 1495 | 90.0 | 42 | 37.4 | 12.0 | 2.1 | 10.0 | 24.1 | 8.0 |
| *Eleusine indica* | 18 | 714 | 45.0 | 40 | 17.9 | 6.0 | 2.0 | 4.8 | 12.7 | 4.2 |
| *Eragrostis tennela* | 2 | 424 | 5.0 | 212 | 10.6 | 0.7 | 10.5 | 2.8 | 14.0 | 4.7 |
| *Fimbristylis miliaceura* | 1 | 384 | 2.5 | 384 | 9.6 | 0.3 | 19.0 | 2.6 | 21.9 | 7.3 |
| *Galinsoga parviflora* | 2 | 90 | 5.0 | 45 | 2.3 | 0.7 | 2.2 | 0.6 | 3.5 | 1.2 |
| *Hackalia uncinata* | 6 | 536 | 15.0 | 89 | 13.4 | 2.0 | 4.4 | 3.6 | 10.0 | 3.3 |
| *Ipomoea pestigridis* | 5 | 195 | 12.5 | 39 | 4.9 | 1.7 | 1.9 | 1.3 | 4.9 | 1.6 |
| *Panicum dichotomiflorum* | 14 | 740 | 35.0 | 53 | 18.5 | 4.7 | 2.6 | 5.0 | 12.2 | 4.1 |
| *Phyllanthus niruiri* | 9 | 380 | 22.5 | 42 | 9.5 | 3.0 | 2.1 | 2.6 | 7.6 | 2.5 |
| *Physalis minima* | 7 | 163 | 17.5 | 23 | 4.1 | 2.3 | 1.2 | 1.1 | 4.6 | 1.5 |
| *Polygonum alatum* | 2 | 78 | 5.0 | 39 | 2.0 | 0.7 | 1.9 | 0.5 | 3.1 | 1.0 |
| *Setaria glauca* | 7 | 510 | 17.5 | 73 | 12.8 | 2.3 | 3.6 | 3.4 | 9.4 | 3.1 |
| *Others* | 11 | 918 | 27.5 | 83 | 23.0 | 3.7 | 4.1 | 6.2 | 13.9 | 4.6 |

TOI= Total Occurrence of Individuals, TQ= Total Quadrates,TNI= Total Number of Individuals, A= Abundance, D= Density, F= Frequency, RA= Relative Abundance, RD= Relative Density, RF= RelativeFrequency, IVI= Importance Value Index, and SDR= Summed dominance ratio; *Cyperus sp. (C. iria, C. difformis, C. rotundus and C. esculentus).*

**Table 4.** Phytosociology of weeds in maize in Kangra district of Himachal Pradesh during 2018 (Total quadrats,TQ= 40)

| Weed Species | TOI | TNI | D | F | A | RD | RF | RA | IVI | SDR |
|---|---|---|---|---|---|---|---|---|---|---|
| *Aeschynomene indica* | 15 | 80 | 2 | 37.5 | 5.3 | 4.4 | 9.0 | 6.2 | 19.6 | 6.5 |
| *Ageratum conyzoides* | 38 | 1188 | 29.7 | 95.0 | 31.3 | 65.0 | 22.8 | 36.5 | 124.2 | 41.4 |
| *Alternanthera philoxeroides* | 19 | 115 | 2.875 | 47.5 | 6.1 | 6.3 | 11.4 | 7.1 | 24.7 | 8.2 |
| *Amaranthus viridis* | 2 | 4 | 0.1 | 5.0 | 2.0 | 0.2 | 1.2 | 2.3 | 3.8 | 1.3 |
| *Commenlina benghalensis* | 12 | 78 | 1.95 | 30.0 | 6.5 | 4.3 | 7.2 | 7.6 | 19.0 | 6.3 |
| *Cyperus sp* | 1 | 1 | 0.025 | 2.5 | 1.0 | 0.1 | 0.6 | 1.2 | 1.8 | 0.6 |
| *Digitaria sanguinalis* | 15 | 35 | 0.875 | 37.5 | 2.3 | 1.9 | 9.0 | 2.7 | 13.6 | 4.5 |
| *Echinochloa colona* | 29 | 107 | 2.675 | 72.5 | 3.7 | 5.9 | 17.4 | 4.3 | 27.5 | 9.2 |
| *Echinochloa crus-galli* | 8 | 13 | 0.325 | 20.0 | 1.6 | 0.7 | 4.8 | 1.9 | 7.4 | 2.5 |
| *Oxalis sp.* | 4 | 10 | 0.25 | 10.0 | 2.5 | 0.5 | 2.4 | 2.9 | 5.9 | 2.0 |
| *Panicum dichotomiflorum* | 3 | 22 | 0.55 | 7.5 | 7.3 | 1.2 | 1.8 | 8.6 | 11.6 | 3.9 |
| *Phyllanthus niruri* | 13 | 154 | 3.85 | 32.5 | 11.8 | 8.4 | 7.8 | 13.8 | 30.0 | 10.0 |
| *Polygonum alatum* | 6 | 19 | 0.475 | 15.0 | 3.2 | 1.0 | 3.6 | 3.7 | 8.3 | 2.8 |
| *Setaria viridis* | 2 | 2 | 0.05 | 5.0 | 1.0 | 0.1 | 1.2 | 1.2 | 2.5 | 0.8 |

TOI= Total Occurrence of Individuals, TQ= Total Quadrates,TNI= Total Number of Individuals, A= Abundance, D= Density, F= Frequency, RA= Relative Abundance, RD= Relative Density, RF= Relative Frequency, IVI= Importance Value Index, and SDR= Summeddominance ratio; *Cyperus sp. (C. iria, C. difformis, C. rotundus and C. esculentus).*

*Abundance*

Abundance is the study of the number of individuals of different species in the community per unit area. By quadrats method, samplings are made at random at several places and the number of individuals of each species was summed up for all the quadrats divided by the total number of quadrats in which the species occurred. Relative abundance is the abundance of a species (by any measure) divided by the total abundance of all species combined. In 2008, most abundant weed was *Fimbristylis miliacea* followed by *Cyperus difformis*, *Eragostis tennela*, *Ageratum conyzoides*, *Ammania baciferra*, *Bidens pilosa* and *Hackelia uncinata*. After the survey of 2018, we came to the conclusion that *Ageratum conyzoides* was the most abundant weed followed by *Phyllanthus niruri, Panicum dichotomiflorum, Commelina benghalensis, Alternanthera philoxeroides,* and *Aeschynomene indica*.

*Important value index/summed dominance ratio*

Important value index is used to determine the overall importance of each species in the community structure. *Ageratum conyzoides* was the most important weed in 2008 followed by *Echinochloa colona*, *Fimbristylis miliacea*, *Digitaria sanguinalis*, *Bracharia ramose*, *Commelina benghalensis* and *Cyperus iria* in that order. The important value index calculated for individual weed species in the maize field crop in 2018 revealed that *Ageratum conyzoides* was again the most important weed species followed by *Phyllanthus niruri*, *Echinochloa colona, Alternanthera philoxeroides, Aeschynomene indica*, *Commelina benghalensis* and *Digitaria sanguinalis*.

*Aeschynomene indica, Alternanthera philoxeroides, Amaranthus viridis, Echinochloa crusgalli and Oxalis sp.* recorded during 2018 were not found in the survey of 2008. Thus the shift towards these weeds species requiring refined control tactics with emphasis attending them also. This is clearly indicated that a weed management programme especially a good weed management programme is a never ending effort but need implementation with refinement from time to time. Weeds though are always the interfering associates in crop production programmes but the invasion of species like *Alternanthera philoxeroides* in the high rainfall area may be the potential threat in the time to come. *Oxalis sp.* also had been always a major concern of the farmers especially in vegetable fields, might it be a future super weed of maize field in the district Kangra of Himachal Pradesh. The weed species *viz. Ammannia baccifera, Bidens pilosa, Brachiaria ramose, B. reptans, Dactyloctenium aegyptium, Fimbristylis miliaceaum, Galinsoga parviflora, Hackelia uncinata, Ipomoea pestigridis, and Physalis minima* those recorded in 2008 were not found in the survey of 2018.

## Conclusion

The study clearly indicated that weeds are dynamic in nature changing continuously in their composition, density, abundance and frequency over a time period requiring continuous refinement in the management tactics depending upon the associated shifts. So a weed management programme especially a successful weed management programme is a never ending process.

## Conflict of Interest

Authors declare no conflict of interest.

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