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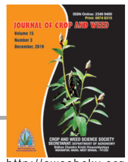

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Weed floristic diversity in maize-garlic organic crop production system under mid-hill conditions of Himachal Pradesh

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ABSTRACT

The research was carried out in a continuing experiment under AICRP-WM (All India Coordinated Research Project on Weed Management) during mid-October, 2017 to third week of September, 2018 at Palampur. The previous year's data were also included to have an insight on shifts in weed flora owing to organic weed management practices. There were 22 weed species in garlic and 19 weed species in maize. Phalaris minor, Daucus carota and Anagallis arvensis were the major weeds constituting 17.0, 14.0 and 12.0 per cent, respectively of the total weed flora in garlic. Commelina benghalensis, Galinsoga parviflora and Ageratum sp. were the major weeds constituting 21.0, 17.0 and 11.0 per cent, respectively of the total weed flora in maize. In garlic, lowest population of grasses was recorded in stale seed bed + mulch being statistically at par with raised stale seed bed + mulch and mulch. Whereas broad-leaved weeds population was lowest in stale seed bed + hoeing being statistically at par with raised stale seed bed + hoeing and hoeing. In maize, population of grasses and sedges was not affected significantly by various weed control treatments. Whereas population of sedges was minimum in raised stale seed bed + hoeing being statistically at par with mulch, intensive cropping, stale seed bed + mulch and intercropping. In garlic, Phalaris minor had greater importance in RSSB + hoeing, intercropping and chemical check treatments. Anagallis arvensis was most important in mulch and SSB + mulch treatments. Coronopus didymus was present in largest amount and was important in crop rotation. Lolium temulentum had highest important value index (IVI) in intensive cropping treatment. Digitaria sanguinalis had highest IVI in SSB + hoeing treatment. Whereas Polygonum alatum was having highest IVI in RSSB + mulch. In maize Commelina benghalensis was having more IVI in hoeing, SSB + hoeing, mulch, RSSB + mulch, crop rotation, intensive cropping and chemical check treatments. However, Galinsoga parviflora was present in large number with more IVI in RSSB + hoeing, SSB + mulch and intercropping treatments.

Keywords: Crop rotation, hoeing, intensive cropping, intercropping, organic, stale seed bed, weed floristic diversity

In India, there were 30 major cropping systems identified (Yadav and Prasad, 1998). Maize based cropping system is the most predominant in rainfed hilly areas. Among different maize-based systems, maize-wheat system is the most widely adopted cropping system of Himachal Pradesh. The mid-hill regions account for more than 41.01 per cent of the cropped area of Himachal Pradesh. In spite of the significant research achievements, the productivity of maize-wheat system is far below the potential yield of the crops. Although, recommendations for improved crop production technologies have been made (CSKHPKV 2017a, b and c), the farmers have not succeeded in taking full advantage of these technologies (Singh *et al.,* 1998). Despite spacious growth of maize-wheat system, reports of stagnation in the productivity, with possible decline in production in future, have raised doubts about its sustainability. The productivity of this existing sequence in small and marginal farmers' field is low. In such circumstances, diversification is the only answer if farmers wish to make their farming profitable. Since maize is one of the potential *kharif* crops of the state, diversification within its cultivation for higher returns is possible through taking up it as green cob depending upon the market demand. During *rabi* season, wheat can be replaced with other crops like vegetables (Saroch *et al.,* 2005). Most farmers are shifting to vegetables owing to unique agro-climatic conditions and fetching reasonably good price and income. Earlier studies have indicated superiority of alternative vegetable-based cropping systems *viz.*, maize – garlic over the traditional cropping systems (Sharma *et al.,* 2007 and 2009; Rana *et al.,* 2010 and 2011). Organic management of maize-vegetable based system may further improve resource use efficiency, family employment and income, besides, achieving the wider national goals of sustainability and overall ecological health. However, weed menace is the major factors influencing the uptake of organic production. The battle against weeds is never ending and it is often the costliest agronomic input for successful crop production. Among the various yield limiting factors, weeds are the most serious problem both in

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maize and garlic as they compete with the crops for various growth factors such as nutrients, moisture, light and space. Weeds make rank growth in this crop due to wider row spacing of maize and high fertilizers application. Moreover, sowing of maize is done after one pre-sowing irrigation and later irrigation is applied based on rainfall and the favourable soil moisture along with congenial temperature conditions encourage weed growth. Similarly, in the non-canopy farming crops like garlic, several flushes of weeds appears consequent upon frequent hand weeding, irrigation and other cultural practices. This leads to severe crop weed competition which culminates in heavy reduction in growth and yield of the crops and lessens the profitability depending upon intensity, type of weed flora and nature of weed growth in relation to environmental conditions at or after sowing. It is therefore, imperative to study weed floristic diversity under maize – garlic organic crop production system to have sound and effective organic weed management system under mid-hill conditions of Himachal Pradesh.

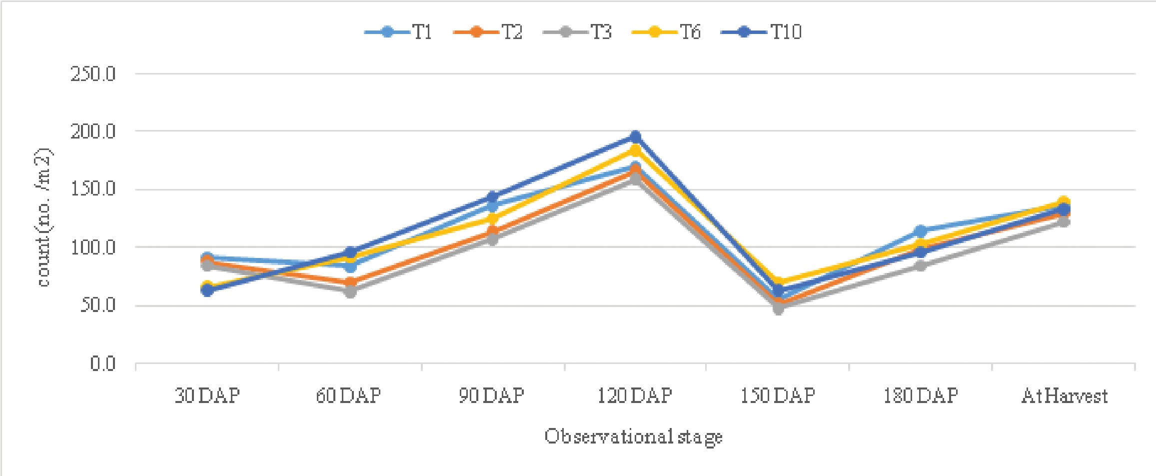
The study was carried out in a continuing experiment under AICRP-WM (All India Coordinated Research Project on Weed Management) during 17th October, 2017 to 19th September, 2018 at the research farm of Department of Agronomy, Forages and Grassland Management, CSK HP Krishi Vishvavidyalaya, Palampur. Ten weed control treatments based on T_1- hoeing, T_2- stale seed bed + hoeing, T_3- raised stale seed bed + hoeing, T_4- mulch(Lantana) @ 5t ha^{-1}, T_5- stale seed bed + mulch, T_6- raised stale seed bed + mulch, T_7- intercropping, T_8- crop rotation, T_9- intensive cropping and T_{10}- chemical check (Table 1) were evaluated in RBD with three replications.

The soil (0-15 cm) was acidic in reaction (pH 5.8), silty clay loam in texture, medium in organic carbon (0.72%), high in available P (41.1 kg ha^{-1}), medium in available K (198.7 kg ha^{-1}) and N (270.5 kg ha^{-1}). During *rabi* (2017-18) maximum temperature ranged between 16.0 and 29.9°C (2nd and 20th meteorological week, respectively). The minimum temperature ranged between 3.1 and 17.6°C (2nd/4th and 19th meteorological week, respectively). Total amount of rainfall received was 466.9 mm. During the crop season, highest amount of rainfall (104 mm) was received in 6th meteorological week. During *kharif* (2018), the maximum temperature ranged between 20.0 and 30.6°C (46th and 23rd meteorological week, respectively). The minimum temperature ranged between 7.0 and 20.6°C (45th and 23rd meteorological week, respectively). Total amount of rainfall received was 3132.4 mm. During the crop season, the highest amount of rainfall (310.8 mm) was received in 34th meteorological week.

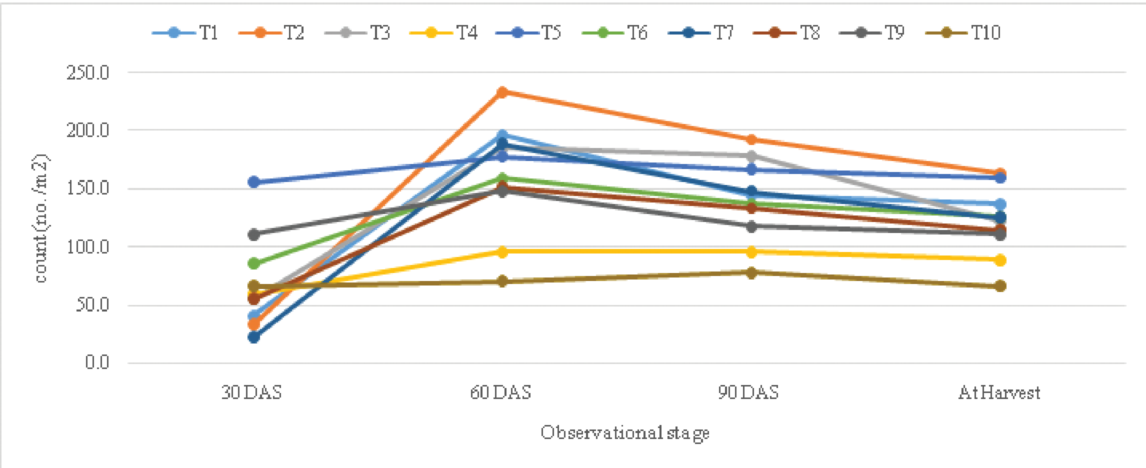
Garlic crop variety Agrifound Parvati (G-313) was sown on 17th October, 2017 at a spacing of 20 ×10 cm using a seed rate of 500 kg ha^{-1} and harvested on 12th May, 2018. The maize crop variety Kanchan Hybrid was sown on 4th June at a spacing of 60 × 20 cm and harvested on 19th September 2018. One pre-sowing irrigation was given. Thereafter, the crop met its water requirement through rainfall, which was very high during the entire crop growth period. The nutrient requirement was met out through FYM and Vermicompost. The plant protection measures whenever needed were also taken through organics.

Observations on weed count and dry weight were recorded, species-wise at monthly interval and at harvest from 30 × 30 cm quadrate at two places in each plot. The weed count and dry weight so obtained were converted to number and grams per square metre, respectively by multiplying the average count and dry weight of the weeds with factor 11.11. The statistical analysis of data was done by using the techniques of analysis of variance as described by Gomez and Gomez (1984). Square-root transformation ($\sqrt{x}$ +0.5) of data on weed density was carried out prior to analysis. Important value index (IVI) was used to determine the overall importance of each species in a cropping sequence. This IVI was calculated by the percentage values of the relative frequency [Total no. of occurrence of the species/no. of occurrence of all the species x 100], relative density [Total no. of individuals of the species/ Number of individuals of all the species x 100] and relative abundance [Total number of individuals of a species in all quadrats/ Total no. of individuals of all species in all quadrats x 100] were summed up together and the value was referred as IVI of the species.

There were 22 weed species found growing in garlic in different weed control treatments (Table 2). *Vicia sativa*, *Asphodelus tenuifolius*, *Anagallis arvensis*, *Poa annua*, *Coronopus didymus*, *Phalaris minor*, *Daucus carrota*, *Euphorbia helioscopia* and *Chenopodium murale* had shown their occurrence in all the treatments. The rest of the species were sporadically present in some treatments. In 'chemical check' 15 species in garlic were found associated. Twelve to fifteen weed species were common in 'chemical check' and the alternative weed control treatments in garlic. In garlic, 1 to 6 weed species were different from 'chemical check' in alternative weed control treatments. Data clearly indicated that with changes in weed control methods, variation in infestation of weed flora occurred. With the controlling/eradicating/ limiting one species, another species found its way to invade the agro-ecosystem indicating that weed control and especially the successful weed control is a never-ending process rather a continuous effort. This may truly



Garlic



Maize

Fig. 1: Total weed count (no./m^2) in garlic and maize

happen in a crop like garlic which is always a non-canopy forming.

There were 19 weed species found growing in maize during 2018 in different weed control treatments. In 'chemical check' 10 species in maize were found growing. Eight to nine weed species were common in 'chemical check' and alternative weed control treatments in maize. In maize, 2 to 6 weed species were found different from 'chemical check' in alternative weed control treatments. Data indicated that with changes in weed control methods, variation in infestation of weed flora occurred. With the controlling/eradicating/limiting one species, another species found its way to invade the agro-ecosystem indicating that weed control and especially the successful weed control is a never-ending process rather a continuous effort. This may truly happen in a crop like maize which is mostly a widely spaced and experiencing frequent heavy rains in *kharif* especially under Palam valley conditions.

For the study of weed shifts the data for the preceding year was referred. In garlic**,** weed flora was diverse because of diversity of management practices with twenty-two species in garlic as mentioned earlier. Weed flora in garlic was dominated by *Phalaris minor* (17.1%), *Daucus carrota* (14.1%), *Anagallis arvensis* (12.5%), *Poa annua* (8.9%), *Asphodelus tenuifolius* (8.9%), *Euphorbia helioscopia* (8.5%), *Vicia sativa* (7.2%), *Coronopus didymus* (4%) and *Tulipa* sp. (3.6%). Association of these weeds with garlic has been reported by Kumar *et al.* (2003). Weed flora during *kharif* 2017 was dominated by *Echinochloa* sp. (42.3%), *Ageratum* sp. (*Ageratum conyzoides* and *Ageratum houstonianum*) (21.6%), *Commelina benghalensis* (9.8%), *Digitaria sanguinalis* (8%), *Cyperus* sp. (7.4%), *Polygonum*

Table 1: Treatment details

Treatment	*Kharif*	*Rabi*	Remarks/short title
	Maize (Green cob)	**Garlic**	
T_1	Hoeing followed by earthing up at knee high stage	Hoeing at 15 DAS & 45 DAS	Hoeing
T_2	Stale seed bed (SSB) + hoeing + earthing up	SSB + hoeing + HW	SSB + hoeing
T_3	Raised stale seed bed (RSSB)+ hoeing + earthing up	RSSB + hoeing + HW	RSSB + hoeing
T_4	Mulch (Lantana) @ 5t/ha	Mulch @ 5 t/ha	Mulch
T_5	SSB + mulch @ 5t/ha	SSB + mulch@5t/ha	SSB + mulch
T_6	RSSB + mulch @ 5t/ha	RSSB + mulch@5t/ha	RSSB + mulch
T_7	Intercropping (soybean) + hoeing	Intercropping (Coriander) + hoeing	Intercropping
T_8	*Maize/Soybean + hoeing+ earthing up	*Garlic/Pea + hoeing+ HW	Crop rotation
T_9	Mulch + manual weeding fb autumn crop of coriander	Mulch + manual weeding fb summer crop of green manure	Intensive cropping
T_{10}	Chemical check	Chemical check	Chemical check

*In *kharif*, maize/soybean and in *rabi* garlic/pea as alternate crop

Table 2: Effect of weed management practices on Shannon Weir Index of weeds in garlic andmaize

	Treatment	No. of weed species common as T_{10}		No. of weed species present in new system but absent in T_{10}	
		Garlic	**Maize (2018)**	**Garlic**	**Maize (2018)**
T_1	Hoeing	14	8	3	3
T_2	SSB + hoeing	14	9	2	5
T_3	RSSB + hoeing	13	9	2	4
T_4	Mulch	12	9	6	2
T_5	SSB + mulch	13	8	4	6
T_6	RSSB + mulch	12	8	2	3
T_7	Intercropping	13	8	4	2
T_8	Crop rotation	15	9	1	5
T_9	Intensive cropping	15	9	3	5
T_{10}	Chemical check	15	10	-	-

Table 3:**Effect of treatments on category-wise weed count in garlic (seasonal averages)**

Treatment		Grasses	Broad-leaved	Total
T_1	Hoeing	6.1 (38)	8.7 (75)	10.6 (113)
T_2	SSB + hoeing	6.6 (43)	7.8 (60)	10.2 (103)
T_3	RSSB + hoeing	5.9 (35)	7.8 (61)	9.8 (96)
T_4	Mulch	5.5 (31)	11.2 (124)	12.5 (155)
T_5	SSB + mulch	5.0 (25)	9.9 (98)	11.1 (123)
T_6	RSSB + mulch	5.1 (25)	9.0 (80)	10.3 (106)
T_7	Intercropping	6.3 (40)	9.5 (90)	11.4 (130)
T_8	Crop rotation*	6.7 (45)	10.1 (102)	12.1 (147)
T_9	Intensive cropping	6.1 (37)	9.8 (95)	11.5 (131)
T_{10}	Chemical check	5.9 (34)	8.9 (79)	10.6 (113)
	SE(m±)	**0.2**	**0.3**	**0.3**
	LSD (P=0.05)	**0.7**	**1.0**	**0.9**

** Maize-garlic and soybean-peas alternatively; Values in parentheses are means of original values; Data transformed to square root transformation ($\sqrt{x+0.5}$)*

Table 4:Effect of treatments on category-wise weed count in maize (seasonal averages)

Treatment		Maize (2017)				Maize (2018)			
		Grasses	Sedges	Broad-leaved	Total	Grasses	Sedges	Broad-leaved	Total
T_1	Hoeing	16.7	4.9	10.1	20.4	6.1	4.1	8	11
		(277)	(32)	(107)	(416)	(42)	(16)	(64)	(122)
T_2	SSB + hoeing	18.7	4.5	16.3	25.5	7.8	5.1	7.4	12.1
		(352)	(27)	(283)	(661)	(64)	(30)	(54)	(148)
T_3	RSSB + hoeing	16.8	0.7	10.8	20.0	7.5	0.7	8.5	11.3
		(283)	(0)	(117)	(400)	(59)	(0)	(74)	(133)
T_4	Mulch	16.0	3.7	13.4	22.3	6	1.6	5.8	8.6
		(299)	(32)	(181)	(512)	(36)	(4)	(36)	(75)
T_5	SSB + mulch	19.6	4.5	14.2	25.1	7.8	2.7	8.9	12.2
		(384)	(27)	(229)	(640)	(60)	(9)	(80)	(149)
T_6	RSSB + mulch	17.0	2.8	11.6	20.9	7.9	3.2	6.9	10.9
		(288)	(16)	(139)	(443)	(62)	(10)	(48)	(120)
T_7	Intercropping	17.7	7.5	16.3	25.4	4.7	3.0	8.3	10.3
		(315)	(59)	(283)	(656)	(22)	(11)	(79)	(112)
T_8	Crop rotation	17.0	2.4	15.5	23.4	6.2	3.3	7.1	10.1
		(288)	(11)	(251)	(549)	(38)	(14)	(52)	(104)
T_9	Intensive cropping	19.5	7.5	13.6	25.7	6.5	1.8	8.2	10.7
		(379)	(69)	(213)	(661)	(42)	(5)	(68)	(115)
T_{10}	Chemical check	12.4	7.3	19.5	25.3	5.2	3.3	5.6	8.5
		(176)	(91)	(379)	(645)	(27)	(14)	(31)	(72)
	SE(m±)	**2.0**	**1.9**	**2.5**	**1.9**	**1**	**0.8**	**1**	**1.1**
	LSD (P=0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**2.4**	**NS**	**NS**

** Values in parentheses are means of original values; Data transformed to square root transformation (“x+0.5)*

Table 5:Effect of treatments on IVI (Important value index) of different weed species in garlic

	Weed species	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}
1	*Vicia sativa*	17.1	22.9	23.8	48.6	23.8	22.3	24.5	31.3	29.2	30.5
2	*Asphodelus tenuifolius*	20.0	29.8	22.7	44.9	24.3	20.8	35.2	65.7	23.4	49.7
3	*Anagallis arvensis*	28.6	31.9	29.8	51.0	49.1	52.1	27.2	40.4	43.1	41.7
4	*Poa annua*	26.5	28.9	33.7	36.0	24.6	23.4	35.4	38.0	40.1	36.9
5	*Coronopus didymus*	10.3	26.0	32.1	34.7	32.7	20.8	41.7	83.3	38.2	31.3
6	*Phalaris minor*	40.5	47.2	47.8	46.9	37.0	42.8	59.2	48.6	41.7	62.5
7	*Daucus carrota*	42.9	33.6	25.0	28.5	45.8	29.8	30.5	68.3	44.4	44.4
8	*Euphorbia helioscopia*	22.7	34.7	32.4	33.9	27.4	35.7	39.9	27.1	46.9	28.8
9	*Chenopodium murale*	7.6	20.8	20.8	27.8	20.8	23.4	20.8	20.8	20.8	41.7
10	*Lolium temulentum*	0.0	0.0	20.8	0.0	0.0	0.0	0.0	55.6	62.5	27.8
11	*Panicum dichotomiflorum*	5.1	20.8	0.0	20.8	41.7	0.0	20.8	0.0	0.0	0.0
12	*Coriandrum tordylium*	9.4	0.0	20.8	20.8	34.7	0.0	20.8	0.0	0.0	0.0
13	*Chenopodium album*	0.0	20.8	0.0	20.8	20.8	0.0	24.3	0.0	20.8	0.0
14	*Galinsoga parviflora*	0.0	0.0	20.8	20.8	0.0	20.8	0.0	0.0	20.8	0.0
15	*Plantago lanceolata*	10.1	20.8	0.0	23.8	48.6	20.8	20.8	20.8	41.7	20.8
16	*Tulipa* sp.	10.3	20.8	20.8	39.8	28.6	0.0	20.8	20.8	33.0	31.3
17	*Stellaria media*	8.8	20.8	20.8	31.3	20.8	27.8	20.8	29.2	48.6	20.8
18	*Rumex obtusifolius*	8.8	0.0	0.0	32.4	0.0	20.8	0.0	0.0	31.3	0.0
19	*Ranunculus arvensis*	0.0	0.0	0.0	0.0	20.8	0.0	26.0	20.8	0.0	0.0
20	*Digitaria sanguinalis*	21.8	55.6	27.8	0.0	0.0	0.0	0.0	27.8	48.6	27.8
21	*Polygonum alatum*	9.4	20.8	0.0	0.0	41.7	55.6	27.8	27.8	20.8	20.8
22	*Medicago denticulata*	0.0	0.0	0.0	27.8	0.0	0.0	0.0	0.0	0.0	0.0

Table 6: Effect of treatments on IVI (Importance value index) of different weed species in maize during 2018

	Weed species	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}
1	*Cynodon dactylon*	0.0	0.0	17.9	0.0	0.0	12.2	0.0	0.0	0.0	7.2
2	*Commelina benghalensis*	42.3	67.5	58.7	47.3	53.5	60.1	30.3	37.3	45.7	37.9
3	*Galinsoga parviflora*	39.5	27.4	69.6	27.3	62.3	33.3	73.7	35.5	45.6	30.1
4	*Bidens pilosa*	0.0	13.2	7.2	7.2	29.1	19.3	22.6	13.2	16.3	20.3
5	*Aeschochymene indica*	31.4	7.2	7.2	7.2	12.2	22.6	12.2	10.2	17.3	7.2
6	*Polygonum alatum*	23.0	22.6	22.3	10.2	24.3	0.0	16.3	20.3	28.3	13.2
7	*Trifolium repens*	0.0	12.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	*Digitaria sanguinalis*	28.3	30.3	32.3	13.3	27.4	22.3	13.2	19.3	13.2	22.3
9	*Echinochloa colona*	0.0	16.3	7.2	0.0	24.3	10.2	0.0	0.0	22.3	0.0
10	*Cyperus* sp.	34.0	52.2	0.0	13.2	22.3	25.7	26.3	30.3	16.3	30.3
11	*Ageratum* sp.	36.3	36.3	28.3	24.3	34.0	37.3	0.0	26.3	26.3	10.2
12	*Phyllanthus niruri*	16.3	20.3	22.6	24.3	0.0	0.0	36.3	10.2	10.2	10.2
13	*Anagallis arvensis*	0.0	0.0	10.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	*Alternanthera philoxeroides*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.2	0.0
15	*Panicum dichotomiflorum*	22.4	13.2	4.2	22.4	10.2	29.1	16.3	16.3	16.3	0.0
16	*Physalis minima*	10.2	10.2	0.0	0.0	19.3	0.0	0.0	20.3	16.3	0.0
17	*Eleusine indica*	0.0	0.0	0.0	0.0	13.3	0.0	0.0	16.3	0.0	0.0
18	*Pasapalum scrobiculatum*	16.3	16.3	19.3	25.3	39.0	22.3	22.3	28.4	26.3	0.0
19	*Setaria viridis*	0.0	0.0	0.0	0.0	10.2	0.0	0.0	13.2	0.0	0.0

T_1- Hoeing, T_2- SSB + hoeing, T_3- RSSB + hoeing, T_4- Mulch, T_5- SSB + mulch, T_6- RSSB + mulch, T_7- Intercropping, T_8- Crop rotation, T_9- Intensive cropping, T_{10}-Chemical check

alatum (6%), *Panicum dichotomiflorum* (2.3%), *Aeschynomene indica* (0.7%) and *Trifolium repens* (0.3%). Weed flora during *kharif* 2018 was dominated by *Commelina benghalensis* (20.5%), *Galinsoga parviflora* (17.4%), *Ageratum* sp. (*Ageratum conyzoides* and *Ageratum houstonianum*) (10.7%), *Cyperus* sp. (9.5%), *Digitaria sanguinalis* (7.3%), *Paspalum scrobiculatum* (6.6%), *Polygonum alatum* (5.4%), *Phyllanthus niruri* (4.7%), *Panicum dichotomiflorum* (4.5%), *Bidens pilosa* (3.7%) and *Aeschynomene indica* (2.7%). *Alter nenthera philoxeroides* also invaded the field but with a low proportion (0.3%) and may be a potential future threat. *Bidens pilosa*, *Eleusine indica*, *Galinsoga parviflora*, *Pasapalum scrobiculatum*, *Phyllanthus niruri*, *Physalis minima*, *Setaria viridis* and *Trifolium repens* were recorded only during *kharif* 2018. Weeds such as *Commelinabenghalensis*, *Digitaria sanguinalis*, *Cyperus* sp., *Polygonum alatum*, *Panicum dichotomiflorum* and *Aeschynomene indica* invaded the field in both seasons. The results are in line with the findings of Chopra and Angiras (2008).

The total weed count in garlic, in general, increased upto 120 DAS and decreased after that because of hand weeding to eliminate the existing weed population to minimize seed bank (Fig. 1). The total weed count again showed increasing trend due to new flushes of earlier weeds and weeds such as *Digitaria sanguinalis*, *Galinsoga parviflora*, *Medicago denticulata*, *Polygonum alatum*, *Ranunculus arvensis* and *Stellaria media* also invaded the field at that time. Weed control treatments significantly influenced the total weed count. The lowest total weed count was recorded with RSSB + hoeing (T_3) which was statistically at par with SSB + hoeing (T_2), hoeing (T_1) and RSSB + mulch (T_6). It may be due to removal of initial flush of weeds. Similar results have also been shown by Chopra and Angiras (2008) in maize. The superior performance of raised stale seed bed may be owed to rapid warming up of the bed due to radiational heating which discourages weed seed germination and thus lower weed count. Similar findings have been reported in peas (Tehria *et al.,* 2014; 2015) and wheat (Kumar *et al.,* 2013; 2015) under similar ecological situations. However, upon stale seed bed treatment weed flush was not obtained to the extent it must be, probably due to lack of optimum conditions for germination.

In maize, total weed count increased upto 60 DAS which showed decreasing trend after that. Owing to reduction in species-wise weed count of almost all species, all the weed control treatments resulted in reduction in total weed count. However, total weed count was not significantly influenced by different weed control treatments. Decrease in weed population after 60 DAS has been reported by Akhtar *et al.* (2015) and Chopra and Angiras (2008).

The category-wise count of weeds in garlic has been summarized in Table 3. During *rabi* 2017-18, weed control treatments gave significant variation in the count of grassy and broad-leaved weeds and thereby total weed count. SSB + mulch (T_5) being at par with RSSB + mulch (T_6) and mulch, resulted in significantly lower count of grasses. SSB + hoeing (T_2) being at par with RSSB + hoeing (T_3) and hoeing (T_1), resulted in significantly lower count of broad-leaved weeds. Low count of grasses and broad-leaved weeds resulted in significantly lower total weed count in RSSB + hoeing (T_3) being at par with SSB + hoeing (T_2), RSSB + mulch (T_6), hoeing (T_1) and chemical check treatments. Higher count of broad-leaved weeds was observed in all the treatments as compared to grasses. This may be due to narrow leaves of garlic due to which broad-leaved weeds get enough space for growth.

During *kharif* 2017 distribution of the weeds was random/sporadic rather than uniform and the count of all the weeds was not significantly affected in spite of large variation between treatments. However, during *kharif* 2018, RSSB + hoeing (T_3) being at par to mulch (T_4), intensive cropping (T_9), SSB + mulch (T_5) and intercropping (T_7) gave significantly lower count of sedges over other treatments. Sindhu *et al.* (2010) also reported superiority of stale seed bed over other weed control methods for controlling sedges. Grasses and broad-leaved weeds were not significantly affected due to treatments (Table 4).

Important value index is used to determine the overall importance of a species under a particular cop-weed environment to have an idea for recommending weed control tactics. In garlic, *Phalaris minor* was present in large number and had greater importance in RSSB + hoeing (T_3), intercropping (T_7) and chemical check (T_{10}) treatments. *Anagallis arvensis* was most important in mulch and SSB + mulch (T_5) treatments. *Coronopus didymus* was present in largest amount and was important in crop rotation. *Lolium temulentum* had highest IVI in intensive cropping treatment. *Digitaria sanguinalis* had highest IVI in SSB + hoeing (T_2) treatment,whereas *Polygonum alatum* was having highest IVI in RSSB + mulch (T_6) (Table 5).

The treatment effects on IVI of different weed species in maize during 2018 are summarized in table 6. A perusal of IVI in table 6 revealed that *Commelina benghalensis* was having more IVI in hoeing (T_1), SSB + hoeing (T_2), mulch (T_4), RSSB + mulch (T_6), crop rotation (T_8), intensive cropping (T_9) and chemical check (T_{10}) treatments. However, *Galinsoga parviflora* was present in large number with more IVI in RSSB + hoeing (T_3), SSB + mulch (T_5) and intercropping treatments.

The findings of the investigation clearly indicated that in the organically managed garlic-maize production there was greater weeds floristic diversity with invasion of 22 species in *rabi* and 19 in *kharif* during 2017-18. Their distribution and importance were greatly varied due to weed management practices. *Vicia sativa Asphodelus tenuifolius*, *Anagallis arvensis*, *Poa annua*, *Coronopus didymus*, *Phalaris minor*, *Daucus carrota*, *Euphorbia helioscopa*, *Chenopodium murale*, *Tulipa* sp. and *Stellaria medi*a were present in all weed control treatments in garlic whereas, distribution of other weeds was sporadic in nature. Similarly, *Commelina benghalensis*, *Galinsoga parviflora*, *Aeschynomene indica* and *Digitaria sanguinalis* were present in all weed control treatments in maize and presence of other weed species was sporadic in nature.

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