Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.6, No.9, 2016

Weed Population Dynamics in Four Year Conservation (CA) and Conventional (CN) Agriculture Plots in Southern Maize belt of Ethiopia

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We greatly appreciate the support from Government of Australia, ACIAR, ICARDA, CIMMYT, SIMILESA and EIAR for funding on farm experimentation and capacity building. We are also grateful to Dr. Mathias Mekuria for editing language and subject matter of this manuscript prior publication.

Abstract
CA methods have become increasingly popular in world due to increasing fuel cost and environmental concern. But, the sustainability of CA systems depends on the development of economical and effective weed management systems. Weed scoring was conducted on plots of conventional (CN) and conservation agriculture (CA) during the main cropping season of 2012 and 2015 in Sidama zone (Loka abya, Boricha and Awassa) with an objective of characterizing weed population dynamics in the permanent plots of maize based production systems. From each location four samples were taken using a 0.5mx 0.5m ($0.25m^2$) quadrant. A total of 27 weed species identified in the base year became 28 weed species in the fourth year. After four years, weeds species composition, frequency, abundance and dominancy were analyzed. There was a shift in weed population from time to time and from location to location. Quantitatively, the broadleaf weeds were found to be the most abundant family under CA systems suggesting that weed management practices should focus more on broad-leaved weeds under CA. conversely, both grass, sedge and broadleaved weeds were common in CN. The findings of this assessment could also provide important information about weed density under CA and CN systems to design site specific weed management strategies for the future as well as to assess weed dynamics under CA agriculture system. Academia, research, development organizations and policy makers shall consider annual weed surveillance to harness newly emerging weed species.
Keywords: CA (conservation agriculture), CN (conventional agriculture), weeds species, frequency, abundance, dominance

1. Introduction

CA systems that minimize soil disturbance are also called direct seeding or minimum tillage and are known to reduce weed seed germination. They have become increasingly popular in world due to increasing fuel cost and environmental concern. But, the sustainability of CA systems depends on the development of economical and effective weed management systems. The weed density in both conservation and conventional agricultural systems depends on production systems, soil and climatic conditions. Since weed emergence and growth are suppressed by physical barrier and shading of the residue, more residue results in better weed control (Swanton *et al*., 1993). CA systems influence weed population differently from conventional agriculture. While weed management relies upon agricultural practices and herbicide use in conventional agriculture systems, weed control in CA systems depends upon herbicides, residue management and cropping systems, and limited agriculture in reduced till systems (Lafond *et al*., 2009). Weed species common to agricultural lands of a given region change over a period of time owing to changes in agricultural practices. Shift in dominant weed species occurs because species differ in their growth habit, survival mechanisms, germination requirements, response to environmental factors and weed herbicide resistance. Example of changing agricultural practices that results in shifts in dominant weed species are (1) monoculture to rotational cropping (2) agriculture alone to agriculture plus herbicides (3) wide row- spacing to narrow row-spacing (4) conventional to CA (5) changing herbicides. Herbicide use can in itself bring about changes in the composition of weed population. Some herbicides control only broad leaved weeds but not grasses and others control grasses but not broad leaves. Santin (2006) stated that the changes from a conventional crop to conservation tillage systems can lead to shifts in weed species composition in a given area. Conservation tillage systems with low soil disturbance tend to leave more weed seeds on the surface where as high disturbance systems bury weeds (Chambers *et al.*, 2006). This significantly influences the density of weed population. According to Mennan and Wasik (2003) herbicide usage, crop rotation, irrigation, fertilizer application are the major factors to change in weed species. The effect of tillage systems on weed population dynamics depends on species, location and environment (Thomas and Frik, 1993). The aim of the study was to assess the dynamics of weed species under four year conservation and conventional agricultural systems that employed various cropping systems.

2. MATERIALS AND METHODS

Four year old conservation and conventional agriculture demonstration plots consisting of six treatments were used for this study. Conservation agriculture systems employed retention of at least 30% residue, zero tillage, growing two or more crops simultaneously in intercropping/relay cropping and round up for weed control. However, conventional tillage plots received manual hand weeding, ploughing five times and growing maize/common beans. There were six treatments namely maize/common bean intercropping under conventional agriculture, maize/common bean intercropping under CA, Maize/cow pea intercropping under CA, Sole maize under CA, Sole common bean under CA, and Maize/common bean rotation under CA. These treatments were laid in completely randomized block design (RCBD) by using farmers as replicates in each district. Boricha district represents moisture stressed environment with sandy soils, Loka abaya represents moisture stressed environment with clay loam soils where as Awassa represents mid altitude areas with sandy loam soils. The weed density scoring was done in each permanent plot at farmers' field in Loka abaya, Boricha and Hawassa districts of Sidama zone during main cropping season of 2012 and 2015. A quadrant with a 0.5m x 0.5m ($0.25m^2$) sampling area was used to sample the weed species. Four samples were taken from each plot in each location. Observation, identification and counting of individual weed species were thoroughly undertaken. The number of individuals of each weed species in each quadrant was counted and their frequency, abundance and dominance level of each weed species were determined using the standard sampling procedures and analysis tools as follows.

Frequency: is the percentage of sampling plots on which particular weed species was found. It explains how often a weed species occurs in the survey area:

F = 100*X/N: Where, F = frequency of a particular weed species; X = number of samples in which a particular weed species occurred; N=total number of samples

Abundance: population density of weed species expressed as the number of individuals that species per unit area: (A = EW/N: Where, A = abundance; EW = sum of individuals of a particular weed species across all samples; N= total number of samples).

Dominance: abundance of an individual weed species in relation to total weed abundance: (D = A*100/EA: Where, D = dominance of particular species; A = Abundance the same species; A = total abundance of all weed species).

3. Results

3.1 Assessment of weed species in the three locations at the start of the study period

A total of twenty seven weed species were recorded in the three locations at the start of experimental period in 2012 (Annex 1). The prevalence of such huge number and diverse families of weeds in such small plots of land (10m x 10m) manifests the richness of weed seed bank in the area, and calls for integrated management options that may reduce the seed bank in subsequent cropping seasons. Out of these 27 weed species, only one type was absent in Awassa area. The presence of more weed species in Awassa sandy loam soils compared to that of Boricha sandy soils or clay loam soils of Loka abaya was due to better fertility of soils in Awassa and also more exposure of Awassa areas (biggest town) to new weed introductions from elsewhere compared to that of Boricha areas.

3.2 Weed population dynamics in sandy loam soils of Awassa

3.2.1 Maize-common bean intercropping under conventional agriculture system (CN)

The most frequently occurred weed species under conventional agriculture maize/common bean intercropping plots were *Galinsoga perviflora* (100), *Digitaria scalarum* (100), *Plantago lanceolata* (91.7), *Medicago polymorpha* (66.7) and new invasive weed spp. (66.7). And next to the above mentioned weed species were *Ageratum conyzoides* (50), *Guizotia scabra* (33.4), *Argemone Mexicana* (25) and *Nicandra physalodes* (16.7). *Leucas martinicensis* (8.4) were least frequently occurred in this agriculture system. The most abundant and dominant weed species under CN maize/common bean inter cropping were *Galinsoga perviflora*, new invasive weed, *Ageratum conyzoids*, *Plantago lanceolata*, *Medicago polymorpha* and *Digitaria scalarum*. *Guizotia scabra. Medicago polymorpha, Argemone Mexicana* were the least abundantly found broad-leaved weeds (Table 1). Thus a number of both grass and broadleaf weeds were prevalent in this cropping system.

Table-1.Weed species composition, frequency, abundance and dominance under conservation and conventional tillage system in Awassa in 2015

T1(under conventional tillage maize/common bean)						
Weed spp.	Family	Life cycle	Morphology	Frequency (%)	Abundance	Dominance
Galinsoga perviflora	*Compositae*	annual	Broadleaf	100	18.42	37.47
Ageratum conyzoides	*Asteraceae*	annul	Broadleaf	50	4.33	8.80
Digitaria scalarum	*Poaceae*	Perennial	Grass	100	6.92	14.07
New invasive weed	*Cruciferae*	annual	Broadleaf	66.7	6.08	12.37
Plantago laceolata	*Plantagoceae*	annual	Broadleaf	91.7	5	10.17
Medicago polymorpha	*Fabaceae*	annual	Broadleaf	66.7	4	8.14
Guizotia scabra	*Compositae*	annual	Broadleaf	33.4	1.66	3.37
Nicandra physaloides	*Solonaceae*	annual	Broadleaf	16.7	0.75	1.52
Argemone mexicana	*Papaveraceae*	annual	Broadleaf	25	2	4.06
Leucus martinicensis	*Lamiaceae*	annual	Broadleaf	8.4	-	-
T2 (under conservation tillage maize/common bean intercropping)						
Galinsoga perviflora	*Compositae*	Annual	Broadleaf	100	6.08	12.97
Agiratum conyzoides	*Asteraceae*	Annual	Broadleaf	83.4	6.08	12.97
Digitaria scalarum	*Poaceae*	Perennial	Grass	91.7	12.67	27.08
New invasive weed	*Cruciferae*	Annual	Broadleaf	66.7	11.67	24.90
Plantago laceolata	*Plantagoceae*	Annual	Broadleaf	83.4	7	14.94
Medicago polymorpha	*Fabaceae*	Annual	Broadleaf	58.4	2	4.27
Guizotia scsbra	*Compositae*	Annual	Broadleaf	25	0.67	1.43
Nicandra physalodes	*Solonsceae*	Annual	Broadleaf	33.4	0.34	0.43
Argimone Mexicana	*Papaveraceae*	Annual	Broadleaf	-	0.34	0.43
T3(under conservation tillage maize/cowpea inter cropping)						
Galinsoga perviflora	Compositae	annual	Broadleaf	91.7	7.42	17.07
Ageratum conyzoides	Asteraceae	annual	Broadleaf	83.4	6.08	13.94
Digitaria scalarum	Poaceae	perennial	Grass	100	6.17	14.15
New invasive weed	Cruciferae	annual	Broadleaf	91.7	13.08	30.00
Plantago laceolata	Plantagoceae	annual	Broadleaf	75	5.92	13.58
Medicago polymorpha	Fabiaceae	annual	Broadleaf	91.7	4.25	9.74
Guizotia scsbra	Compositae	annual	Broadleaf		0.67	1.53
Nicandra physalodes	Solonaceae	annual	Broadleaf	8.4	-	-
Argimone mexicana	Papaveraceae	annual	Broadleaf	8.4	-	-
T4(under conservation tillage sole maize cropping)						
Galinsoga perviflora	*comepositae*	Annual	Broadleaf	83.4	8.17	29.38
Ageratum conyzoides	*Asteraceae*	Annual	Broadleaf	66.7	2.08	7.48
Digitaria scalarum	*Poaceae*	perennial	Grass	91.7	4.58	16.47
New invasive weed	*Cruferaceae*	Annual	Broadleaf	100	9.58	34.46
Plantago laceolata	*Plantagoceae*	Annual	Broadleaf	75	2.64	9.49
Medicago polymorpha	*Fabiaceae*	Annual	Broadleaf	41.7	0.75	2.69
Nicandra physalodes	*Solonaceae*	Annual	Broadleaf	16.7	-	-

T5(under CT sole common bean cropping)						
Galinsoga perviflora	*Compositae*	Annual	Broadleaf	100	7.67	8.34
Ageratum conyzoides	*Asteraceae*	Annual	Broadleaf	91.7	6	8.33
Digitaria scalarum	*Poaceae*	Perennial	Grass	91.7	6.58	8.32
New invasive weed	*Cruciferae*	Annual	Broadleaf	100	9.42	8.34
Plantago laceolata	*Plantagoceae*	Annual	Broadleaf	83.4	3.9	8.29
Medicago polymorpha	*Fabiaceae*	Annual	Broadleaf	58.4	2.58	8.32
Guizotia scsbra	*Compositae*	Annual	Broadleaf	16.7	-	-
Nicandra physalodes	*Solonaceae*	Annual	Broadleaf	16.7	-	-
T6(under CT maize/common bean rotation)						
Galinsoga perviflora	*Compositae*	Annual	Broadleaf	91.7	6.33	8.32
Ageratum conyzoides	*Asteraceae*	Annual	Broadleaf	91.7	4.75	8.33
Digitaria scalarum	*Poaceae*	Perennial	Grass	100	4.25	8.33
New invasive weed	*Cruciferae*	Annual	Broadleaf	83.4	8.33	8.33
Plantago laceolata	*Plantagoceae*	Annual	Broadleaf	91.7	9.83	8.33
Medicago polymorpha	*Fabiaceae*	Annual	Broadleaf	75	8.08	8.32
Guizotia scsbra	*Compositae*	Annual	Broadleaf	-	-	-
Nicandra physalodes	*Solonaceae*	Annual	Broadleaf	8.4	-	-
Argimone mexicana	*Papaveraceae*	Annual	Broadleaf	-	-	-
Leucas martinicensis	*Lamiaceae*	Annual	Broadleaf	-	-	-

Source: Data counted in the experimental plot in the fifth year

3.2.2 Maize – common bean intercropping under CA system

Under CA maize/common bean inter cropping *Galinsoga perviflora*, *Ageratum conyzoids*, new weed species, *Plantago lanceolata*, *Medicago polymorpha*, *Nicandra physalodes*, and *Guizotia scabra* were the most frequently found. *Digitaria scalarum*, new invasive weed species and *Plantago lanceolata* were the most abundantly occurred. *Galinsoga perviflora* and *Ageratum conyzoids* were intermediary inn abundance where as *Guizotia scabra*, *Nicandra physalodes* and *Argemone mexicana* were the least abundant.

3.2.3 Maize - cow pea intercropping under CA system

Digitaria scalarum and new weed species were the most dominantly found under this cropping system. Under maize/cow pea inter cropping system the most frequently occurred weed species were *Digitaria scalarum*, *Galinsoga perviflora*, *Medicago polymorpha, Ageratum conyzoids, Plantago lanceolata,* and new invasive weed and the remaining occurred sporadically. New weed species was the most abundant and dominant over all weed species noted in this cropping system (Table 1).

3.2.4 Maize-sole cropping under CA system

Under CA based sole maize cropping system, the greatest number of weed species was frequently recorded. However, new invasive weed was abundantly and dominantly occurred than the rest weed species. More weed species that occurred frequently were broad leaved species including new invasive weed species. *Digitaria scalarum* was the most dominant weed species from grass species (Table 1).

3.2.5 Sole common bean based cropping under CA system

Sole common bean cropping under CA system had been infested with majority of broad leaved weed species similar to that of sole maize cropping under the same tillage condition. However, the level of infestation was differing by the species except new invasive weed (which was uniformly occurred under all agricultural systems due to its late emergence) (Table 1).

3.2.6 Maize-common bean rotation under CA system

Under maize-common bean rotation cropping system *Digitaria scalarum* was the most frequently occurred grass weed species. *Plantago lanceolata*, *Medicago polymorpha*, new invasive weed species were the three abundantly occurred broad-leaved weed species. *Galinsoga perviflora, Ageratum conyzoids, Digitaria scalarum*, new invasive weed species, *Plantago lanceolata* and *Medicago polymorpha* were the most equally dominantly occurred species under CA maize-common bean rotation cropping system (Table 1)**.**

3.3 Weed population dynamics in sandy soils of Boricha

3.3.1 Maize-common bean intercropping under conventional agriculture system

According to the results, *Ageratum conyzoides*, *Commelina benghalensis*, *Polygonium nepalensis*, *Digitaria abyssinicum* and *Cyprus* spp were the most abundant. However, *Galinsoga perviflora, Nicandra physalodes* and *Plantago lanceolata* were least abundant weed species under conventional agriculture maize-common bean intercropping system (Table 2).

3.3.2 Maize - cow pea inter cropping under CA system

Under CA maize - cow pea intercropping system, *Ageratum conyzoides* (55.63) was the most abundant over other weed species and dominantly (93.32) infest the study area. *Commelina* spp. (2.35), *Digitaria abyssinicum (1), and Galinsoga perviflora* (0.13) had occurred least abundantly under this cropping system (Table 2).

3.3.3 Maize-common bean inter cropping under CA system

Ageratum conyzoides (42), *Digitaria abyssinicum* (5.37), *Commelina* spp. (2.37) were the major broad leaf weed species that infested under CA maize-common bean inter cropping system and *Galinsoga perviflora*, *Polygonium nepalense* and *Cyprus* spp were the least ones (Table 2).

3.3.4 Sole maize cropping under CA system

Under CA sole maize planting system, *Ageratum conyzoids, Digitaria abyssinicum, and Commelina spp and Galinsoga perviflora* were the most frequently and dominantly occurred weed species. But *Medicago polymorpha, Soncus asper and Leucas martinicens* had occurred rarely under this cropping system (Table 2).

3.3.5 Sole common bean cropping under CA system

As is with sole maize cropping systems, sole common bean cropping maintained the same kind of weed species infesting the crops. Weeds like *Commelina spp, Galinsoga perviflora, Ageratum conyzoids* and *Digitaria abysssinicum* were the most abundant and dominant weed species. *Cyperus* spp was least dominant weed species (Table 2).

3.3.6 Rotation cropping of maize with common bean under CA system

Under CA rotation cropping system, *Ageratum conyzoids, Digitaria abyssinicum, Galinsoga perviflora, Commelina* spp were the most frequently distributed species under rotation cropping system. *Polygonium nepalense* and *Cyprus* spp were the least occurred weed species under this cropping system (Table 2).

Table-2.Weed species composition, frequency, abundance and dominance under conservation and conventional tillage system in Boricha in 2015

T1(under conventional tillage maize/common bean intercropping)						
Weed spp.	Family	Life cycle	Morphology	Frequency (%)	Abundance	Dominance
Ageratum conyzoides	*Asteraceae*	Annul	Broadleaf	100	44.13	77.43
Commelina spp.	*Commelinaceae*	Annual	Broadleaf	50	2.37	4.15
Galinsoga perviflora	*Compositae*	Annual	Broadleaf	37.5	1.87	3.28
Digitaria abyssinicum	*Poaceae*	Perennial	Grass	75	3.25	5.7
Polygonium nepalensis		Annual	Broadleaf	50	2.37	4.15
Cyprus spp.	*Cyperaceae*	Annual	Sedge	-	2.5	4.38
Nicandra physalodes	*Solanaceae*	Annual	Broadleaf	-	0.25	0.43
Plantago lanceolata	*Plantaginaceae*	Annual	Broadleaf	-	0.25	0.43
T2(under conservation agriculture maize with cow pea intercropping)						
Ageratum conyzoides	*Asteraceae*	Annul	Broadleaf	100	55.63	93.32
Commelina spp.	*Commelinaceae*	Annual	Broadleaf	62.5	2.25	3.94
Galinsoga perviflora	*Asteraceae*	Annual	Broadleaf	37.5	0.13	0.22
Digitaria abyssinicum	*Poaceae*	Perennial	Grass	87.5	2.37	1.76
Polygonium nepalensis	*Polygonaceae*	Annual	Broadleaf	50	-	-
Cyprus spp.	*Cyperaceae*	Annual	Sedge	12.5	0.5	0.83

T3(under conservation agriculture maize with common bean intercropping)						
Ageratum conyzoides	*Asteraceae*	Annul	Broadleaf	100	42	83.18
Digitaria scalarum	*Poaceae*	Perennial	Grass	100	5.37	10.63
Commelina spp.	*Commelinaceae*	Annual	Broadleaf	75	2.75	5.44
Galinsoga perviflora	*Compositae*	Annual	Broadleaf	25	-	-
Polygonium nepalensis	*Cruciferae*	Annual	Broadleaf	25	0.37	0.73
Cyprus spp.	*Cyperaceae*	Annual	Sedge	-	-	-
T4(under conservation agriculture sole maize cropping)						
Commelina spp.	*Commelinaceae*	Annual	Broadleaf	87.5	2.87	7.13
Galinsoga perviflora	*Compositae*	Annual	Broadleaf	25	0.37	0.91
Ageratum conyzoides	*Asteraceae*	Annul	Broadleaf	100	31.13	77.36
Digitaria scalarum	*Poaceae*	Perennial	Grass	100	4.87	12.10
Medicago polymorpha	*Fabiaceae*	Annul	Broadleaf	-	0.5	1.24
Sonchus asper	*Compositae*	Annul	Broadleaf	-	0.25	0.62
Leucas matinicensis	*Lamiaceae*	Annul	Broadleaf	-	0.25	0.62
T5(under CT sole common bean cropping)						
Commelina spp.	Commelinaceae	Annual	Broadleaf	62.5	2.13	4.39
Galinsoga perviflora	Compositae	Annual	Broadleaf	87.5	7.25	14.94
Agiratum conyzoides	Asteraceae	Annul	Broadleaf	100	25.87	53.34
Digitaria abyssinicum	Poaceae	Perennial	Grass	100	11	22.68
Medicago polymorpha	Fabiaceae	Annual	Broadleaf	-	1.25	2.57
Cyperus spp.	Cyperaceae	Annual	Sedge	25	0.37	0.76
Giuzotia scabra	Compositae	Annual	Broadleaf	-	0.63	1.29
T6(under conservation agriculture rotation maize with common bean)						
Commelina spp.	*Commelinaceae*	Annual	Broadleaf	75	1.87	7.12
Galinsoga perviflora	*Compositae*	Annual	Broadleaf	50	5.75	21.90
Ageratum conyzoides	*Asteraceae*	Annul	Broadleaf	100	11	41.90
Digitaria scalarum	*Poaceae*	Perennial	Grass	87.5	3.75	14.28
Polygonium nepalensis	*Cruciferae*	Annual	Broadleaf	12.5	1.75	6.66
Cyprus spp.	*Cyperaceae*	Annual	Sedge	12.5	0.5	1.90
Medicago polymorpha	*Fabiaceae*	Annual	Broadleaf	-	1.63	6.20

Source: Data counted in the experimental plot in the fifth year

3.4 Weed population dynamics in clay loam soils of Loka Abaya

3.4.1 Maize-common bean intercropping under CA system

In Loka abaya clay soils, conventional agriculture maize-common bean intercropping system possessed A*geratum conyzoides and Commelina* spp. most abundantly and dominantly. These weeds are troublesome weed species for this cropping system. *Guzotia scabra, Galinsoga perviflora, Bidens pilosa, Cyprus spp, Pennisatum spp, Eleusine indica and Setaria* species were relatively abundantly occurred weed species (Table 3).

3.4.2Maize-cow pea inter cropping under CA system

With this CA maize-cow pea inter cropping system *Ageratum conyzoids* was the most abundantly occurred weed species. But also *Commelina* spp, *Ageratum conyzoids* and *Digitaria abyssinicum* were the most frequently found under all sampled areas (Table 3).

3.4.3 Sole maize cropping under CA system

Ageratum conyzoids, Commelina spp, Galinsoga perviflora were the most frequently occurred from broadleaf weed species and *Digitaria abyssinicum, Cynodon dactylon, Pennisatum spp, Setaria spp and Eleusine indica* were relatively abundant weeds from grass weeds under this cropping system. But *Cyprus* spp was dominant from the sedge (Table 3).

3.4.4 Under CA sole maize cropping

Ageratum conyzoides occurred abundantly and dominantly in all studied areas. *Commelina spp, Galinsoga perviflora, Digitaria spp and Pennisatum* spp were the next abundant weed species. In addition to that there was weed dynamics among species across sites under the same cropping systems (Table 3). This could be due to variations in soil fertility and also management practices.

Table-3.Weed species composition, frequency, abundance and dominance under conservation and conventional tillage system in Loka Abaya in 2015

T1(Under Conventional tillage maize-common bean intercropping)						
Weed spp.	Family	Life cycle	Morphology	Frequency (%)	Abundance	Dominance
Commelina spp.	*Commelinaceae*	Annual	Broadleaf	62.5	19.87	26.38
Galinsoga perviflora	*Compositae*	Annual	Broadleaf	50	5.37	7.13
Ageratum conyzoides	*Asteraceae*	Annul	Broadleaf	100	38.5	51.12
Digitaria scalarum	*Poaceae*	Perennial	Grass	50	5.5	7.3
Bidens pilosa.	*Asteraceae*	Annual	Broadleaf	-	1.1	1.46
Cyprus spp.	*Cyperaceae*	Annual	Sedge	37.5	2.6	3.45
Pennisatum spp	*Poaceae*	Perennial	Grass	-	0.37	0.49
Eleusine indica	*Poaceace*	Annual	Grass	-	0.5	0.66
Setaria spp.	*Poaceae*	Annual	Grass	37.5	1.5	1.99
T2((under CT maize-cow pea inter cropping)						
Commelina spp.	*Commelinaceae*	Annual	Broadleaf	100	11.5	5.54
Galinsoga perviflora	*Compositae*	Annual	Broadleaf	62.5	4.12	1.98
Ageratum conyzoides	*Asteraceae*	Annul	Broadleaf	100	17.6	83.19
Digitaria scalarum	*Poaceae*	Perennial	Grass	75	8.75	4.21
Bidens pilosa	*Compositae*	Annual	Broadleaf	12.5	0.5	0.24
Cyprus spp.	*Cyperaceae*	Annual	Sedge	12.5	10.0	4.81
Cynodon dactylon	*Poaceae*	Annual	Grass	12.5	-	-
Pennisatum spp	*Poaceae*	Annual	Grass	-	-	-
T3(under conservation tillage maize-common bean inter cropping)						
Commelina spp.	*Commelinaceae*	Annual	Broadleaf	87.5	8.5	9.66
Galinsoga perviflora	*Compositae*	Annual	Broadleaf	75	7.62	8.66
Ageratum conyzoides	*Asteraceae*	Annul	Broadleaf	100	57.25	65.08
Digitaria scalarum	*Poaceae*	Perennial	Grass	50	4.6	5.22
Bidens pilosa.	*Compositae*	Annual	Broadleaf	25	2.0	2.27
Cyprus spp.	*Cyperaceae*	Annual	Sedge	37.5	2.87	3.26
Cynodon dactylon	*Poaceae*	Annual	Grass	12.5	-	-
Pennisatum spp	*Poaceae*	Annual	Grass	25	2.5	2.84
Setaria spp.	*Poaceae*	Annual	Grass	-	0.37	0.42
Eleusine indica	*Poaceae*	Annual	Grass	25	2.25	2.55
T4(under conservation tillage sole maize cropping)						
Commelina spp.	*Commelinaceae*	Annual	Broadleaf	50	6.5	5.56
Galinsoga perviflora	*Compositae*	Annual	Broadleaf	12.5	1.37	1.17
Ageratum conyzoides	*Asteraceae*	Annul	Broadleaf	100	86.25	73.88
Digitaria scalarum	*Poaceae*	Perennial	Grass	50	16	13.70
Bidens pilosa.	*Compositae*	Annul	Broadleaf	25	1.75	1.49
Cyprus spp.	*Cyperaceae*	Annual	Sedge	25	1.12	0.95
Cynodon dactylon	*Poacae*	Annual	Grass	25	-	-
Pennisatum spp	*Perennial*	Annual	Grass	25	2.87	2.45
Eleusine indica	*Poaceae*	Annual	Grass	-	0.87	0.74
T5(under conservation tillage sole common bean cropping)						
Commelina spp.	*Commelinaceae*	Annual	Broadleaf	100	10.12	9.83
Galinsoga perviflora	*Compositae*	Annual	Broadleaf	87.5	12.12	11.78
Ageratum conyzoides	*Asteraceae*	Annul	Broadleaf	100	63.87	62.10
Digitaria scalarum	*Poaceae*	Perennial	Grass	87.5	14.12	13.72
Bidens pilosa.	*Compositae*	Annual	Broadleaf	12.5	-	-
Cyprus spp.	*Cyperaceae*	Annual	Sedge	25	-	-
Cynodon dactylon	*Poaceae*	Annual	Grass	-	-	-
Pennisatum spp	*Poaceae*	Annual	Grass	12.5	-	-
Setaria spp.	*Poaceae*	Annual	Grass	-	0.62	0.60
Eleusine indica	*Poaceae*	Annual	Grass	12.5	2.0	1.94
T6(under conservation agriculture rotation maize with common bean)						
Commelina spp.	*Commelinaceae*	Annual	Broadleaf	87.5	8.25	10.00
Galinsoga perviflora	*Compositae*	Annual	Broadleaf	75	5.87	7.11
Ageratum conyzoides	*Asteraceae*	Annul	Broadleaf	100	61.75	74.85
Digitaria absynicum	*Poaceae*	Perennial	Grass	75	4.75	5.75
Bidens pilosa.	*Compositae*	Annual	Broadleaf	12.5	1.87	2.26
Cyprus spp.	*Cyperaceae*	Annual	Sedge	25	-	-
Pennisatum spp	*Poaceae*	Annual	Grass	12.5	-	-
Leucas martinicensi	*Lamiaceae*	Annual	Broadleaf	12.5	-	-
Sonchus aspeaceus	*Compositae*	Annul	Broadleaf	25	-	-

Source: Data counted in the experimental plot in the fifth year

3.4.5 Sole common bean cropping under CA system

Commelina spp, Ageratum conyzoids, Galinsoga perviflora and Digitaria species occurred abundantly in this cropping system. *Cyperus spp, Pennisatum spp* and *Eleusine indica* were frequently occurred grass weeds under CA sole common bean cropping (Table 3).

3.4.6 Rotation cropping of maize with common bean under CA

Commelina spp, Galinsoga perviflora, Ageratum conyzoids and *Digitaria abyssicum* were the most abundant weeds under the CA rotation cropping. *Cyprus* spp was the most frequent species from sedge (Table 3).

3.5 Discussion

This study revealed new broadleaved weed species in study plots in 2015 which was not present in 2012 in the area. This weed also occurred in road sides, school compounds and office buildings. It grows vigorously, resists some herbicides, dominates most weeds including *Parthinium* spp., reproduces by seeds and emerges very late in the growing season. However, the biology and management options required for its control are not yet identified. However, it has dominated weeds that occurred in most cropping systems and tillage practices. The presence of new type of aggressive weed in a couple of years calls for great attention by policy makers, developmental organizations, academia and research, and requires careful surveillances every year for successful weed management program.

Galinsoga perviflora and Ageratum conyzoides were most abundant in conventional tillage where as *Ageratum conyzoides* and *Digitaria absynicum* were invariably distributed among cropping system under conservation agriculture in the first few years. As it reached to fourth year, grass and sedges were decreasing dramatically in the fields of CA where as the quantity of grass and sedges were increasing from year to year in the fields of conventional tillage in the study areas. This is in line with findings of Bench-Arnold *et al* (2000), who reported reduced or zero tillage decreases the weed population through creating unsuitable conditions for weed seed germination. The prevalence of *Commelina* spp. in most CA plots unlike most plots of CN is an indication of increment in soil fertility in CA plots, which was in turn due to residue retention, higher microbial activity and reduced soil loss through wind and water erosion. The dominance of *Ageratum conyzoides* and *Digitaria absynicum* in most cropping systems and tillage practices could be attributed to large number of weed seed bank in the soil, which was actually decreasing from year to year in CA plots due to application of round up prior planting common bean, cow pea or maize mixtures. This agrees with findings of Thomas and Frick (1993) and Spandl *et al.(*1999) who associated the extent and direction of weed shift to climate, cropping system and soil type in conservation tillage practices. Rotation plots where conservation agriculture was employed showed the least abundance in most weed species observed across most study areas. This was because crop rotation limits the build-up of weed population, and prevents major weed species shift. Rotation changes the growing conditions from year to year because of the timing of cultivation, mowing, fertilization, herbicide application, and harvesting will be different in each year. Also, weeds tend to prosper in crops that have requirements similar to weeds. Thus rotation seems effective weed management tool that diversifies selection pressure and changes disturbance pattern for problematic weeds and prevents the proliferation of weed species well suited to practices associated with a single crop. The results of all the three locations showed greatest number of weed species in sole crops (maize or common bean) compared to that of intercrops. This could be due to wider inter row spacing available between plants in sole crops which lead to poor canopy coverage and minimal suppression effect on newly emerging weeds.

4. Conclusion and recommendation

In the study areas, CA practices were aged four years. Our findings indicated that maize common bean intercropping reduced weed density and composition compared to mono-cropping of either maize or common bean, and also zero (reduced) tillage reduced weed flora compared to conventional tillage. This has huge implication for reduction of production cost.

A total of 27 weed species were identified in 2012. The number of weed species became 28 in 2015. This was due to addition of one aggressive dominant broadleaved new weed to the areas. The presence of new type of aggressive weed in a couple of years calls for great attention by policy makers, developmental organizations, academia and research, and requires careful surveillances every year for successful weed management and crop production program.

In any of the cropping systems, successful weed control requires a producer's attention throughout the season in order to achieve an optimal yield. However, sole cropping practices are not advisable for small holders of the region mainly due to increments in weed flora and decrements in associated crop yield.

In all locations, the majority of weed population were attributed to specific grass and broad leaved weed species indicated in the study, and as a result suitable management options pertinent to the weed shall be undertaken accordingly. That is weed management tactic or control technique shall focus on those weed species that created troubles for the production systems. We also recommended weed management strategies targeting

dominant weeds under each tillage system. However, to investigate weed dynamics, availability of herbicide resistant weeds or explore weed seed bank in the soils further research should be carried out.

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Annex 1. Major weed species recorded in the study areas in 2012

No	Weed species		Location		
	Botanical name	**Family**	**Boricha**	**Loka Abaya**	**Awassa**
1	*Galinsoga perviflora*	*Compositae*	Present	Present	Present
2	*Ageratum conyzoides*	*Asteraceae*	Present	Present	Present
3	*Digitaria scalarum*	*Poaceae*	Present	Present	Present
4	*Setaria spp*	*Poaceae*	Present	Present	Present
5	*Guizotia scabra*	*Compositae*	Present	Present	Present
6	*Nicandra physalodes*	*Solonaceae*	Present	Present	Present
7	*Cyperus spp*	*Sedge*	Absent	Present	Absent
8	*Guizotia scabra*	*Compositae*	Present	Present	Present
9	*Medicago polymorpha*	*Fabaceae*	Present	Present	Present
10	*Commelina spp.*	*Commelinaceae*	Present	Present	Present
11	*Cynodon dactylon*	*Poaceae*	Absent	Present	Present
12	*Bidens pilosa*	*Compositae*	Present	Present	Present
13	*Tagetes minuta*	*Asteraceae*	Absent	Absent	Present
14	*Eleusine species*	*Poacea*	Present	Present	Present
15	*Euphorbia species*	*Euphorbiacea*	Absent	Present	Present
16	*Amaranthus spinosus*	*Amaranthacea*	Present	Present	Present
17	*Leucas martiniceasis*	*Lamiaeae*	Present	Present	Present
18	*Leunaea cornata*	*Asteracea*	Absent	Absent	Present
19	*Trifolium spp*	*Fabiacea*	Absent	Absent	Present
20	*Sonchus oleraceus*	*Compositae*	Present	Present	Present
21	*Xantium spinosus*	*Compositae*	Absent	Absent	Present
22	*Euphorbia hirtab*	*Euphorbiacea*	Absent	Absent	Present
23	*Solonum indicum*	*Solanacea*	Absent	Absent	Present
24	*Solonum nigrum*	*Solanacea*	Present	Present	Present
25	*Spergula arvenss*	*Caryophyllacea*	Absent	Absent	Present
26	*Celosia trigynal*	*Amaranthacea*	Absent	Present	Present
27	*Stellaria media L*	*Caryophylaceae*	Present	Present	Present

Source: Own data scored in the experimental area in first year