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Effect of the tillage system on the floristic composition and the emergence of weeds in *Allium sativum*

Efecto del sistema de labranza sobre la composición florística y la emergencia de malezas en *Allium sativum*

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ABSTRACT

Keywords:
Garlic
Seedling emergence
Weeds diversity
Zero tillage

In fragile environments, no-tillage (0T) instead of conventional tillage (CT) is desirable to prevent agroecosystem degradation, but there is little information on its implementation in horticulture. This study aimed to investigate the effects of replacing CT with 0T on floristic composition and weed emergence dynamics in a garlic crop, under the hypothesis that the implementation of a 0T system alters the weed community during the initial stage of the transition. Two experiments were carried out following a randomized complete block design with two treatments (garlic crop grown under 0T and CT). In two subsampling per plot, biweekly destructive weed surveys were carried out. Although both tillage systems presented a similar diversity between systems, these weed communities varied by 36% in their species identity, and it was recorded a higher total weed density under CT (P>0.05). Under 0T, anemophilous Asteraceae, such as *Conyza bonariensis* and *Sonchus oleraceus*, tended to increase their presence. Under CT, there was a greater amount of indehiscent fruiting Brassicaceae such as *Raphanus sativus* and *Rapistrum rugosum*. The implementation of *Vicia villosa* as a predecessor crop led to many births due to its capacity for natural reseeding. It is concluded that there are important changes in the species composition and weed emergence patterns immediately after the implementation of 0T compared to CT, suggesting that the filtering pressures exerted by each tillage system favor certain weed species over others. By understanding weed community shifts and critical stages of weed emergence, farmers can improve herbicide application, thereby reducing the excessive use of chemicals and minimizing environmental impact. In addition, this information can help to schedule labor and machinery more efficiently, saving time and production costs.

RESUMEN

Palabras clave:
Ajo
Emergencia de plántulas
Diversidad de malezas
Labranza cero

En ambientes frágiles, la labranza cero (L0) presenta ventajas frente a la labranza convencional (LC) al disminuir la degradación de los agroecosistemas, pero se dispone de escasa información sobre su aplicación en horticultura. El objetivo del presente estudio consistió en determinar la influencia que genera la sustitución de LC a L0 sobre la composición florística y la dinámica de emergencia de malezas en un cultivo de *Allium sativum,* bajo la hipótesis de que la implementación L0 altera la comunidad de malezas durante la fase inicial de transición. Dos experimentos fueron realizados siguiendo un diseño en bloques completamente aleatorizados con dos tratamientos (cultivo de ajo bajo LC y L0). Las prospecciones de malezas fueron determinadas de manera destructiva quincenalmente en dos subáreas por parcela. Aunque ambos sistemas de laboreo presentaron una diversidad similar, la identidad de las malezas varió en un 36% y se registró una mayor densidad de plántulas bajo LC (P>0,05). Bajo L0, las Asteráceas anemófilas, como *Conyza bonariensis* y *Sonchus oleraceus,* tendieron a incrementar su presencia. Bajo LC hubo mayor cantidad de Brasicáceas de fruto indehiscente como *Raphanus sativus* y *Rapistrum rugosum*. La implementación de *Vicia villosa* como cultivo antecesor, acarreó un gran número de nacimientos dada su capacidad de resiembra natural. Se concluye que existen cambios importantes en la composición de las especies y en los patrones de emergencia de las malezas inmediatamente después de la implantación de L0 en comparación con LC, lo que sugiere que las presiones ejercidas por cada sistema de laboreo favorecen a determinadas especies frente a otras. Mediante el conocimiento de los cambios en la comunidad de malezas y los períodos críticos de emergencia de malezas los agricultores pueden mejorar los tratamientos con herbicidas, al reducir el excesivo uso de productos químicos y minimizar el impacto ambiental. Esta información puede asimismo ayudar a programar las labores manuales y mecánicas más eficientemente, reduciendo los costos de producción.

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In semi-arid regions, wind and water soil erosion is a major problem, therefore agricultural practices should aim to reduce it (Lal 2001). The implementation of conventional tillage (CT) contributes to erosion by disturbing the soil, breaking its structure, and reducing its cover, while the adoption of zero-tillage (0T) reduces the amount of sand transported near the field surface and increasing the cohesion of soil particles and the size of aggregates, making them more difficult to erode (Yang et al. 2020).

The transition from CT to 0T modifies soil environmental parameters by directly affecting water dynamics, obstructing light interception, and reducing surface layer temperature and oxygen availability (Nikolić et al. 2021). Each agricultural practice has a higher or lower potential to influence the abundance and diversity of weed species in a crop field and is a key aspect that affects both biodiversity conservation and integrated weed management (Travlos et al. 2018).

The Lower Colorado River Valley Irrigation District (VIRC; Figure 1), Argentina, presents a fragile environment, with a high susceptibility to wind and water erosion of its soils (D'Amico and Varela 2017). The economy is based on irrigated agricultural production with a strong specialization in the horticultural sub-sector, particularly bulb crops under CT, which requires a high proportion of tillage and complementary manual work (Navós López 2021; D'Amico and Varela 2017). While 0T is widespread in Argentina for extensive grain production, it has not yet been developed for vegetable production such as garlic (D'Amico and Varela 2017). Therefore, the available literature for horticultural crops produced under 0T is scarce, especially regarding the floristic composition of weeds that predominate in this new system.

Since the VIRC has a temperate climate, with summers and winters differentiated by marked thermal extremes, weed species vary according to the season in which they develop their cycle. Thus, they are classified as autumn-winter-spring (AWS), germinating in autumn, vegetating in winter, and fructifying in spring, or spring-summer (SS), which germinate in spring and culminating their cycle at the end of the summer. In turn, many species are facultative (AWS-SS) and can develop their cycle partially in both periods, so they have two main peaks of emergence, one in autumn and the other in spring (Cerazo and Conticello 2008).

Garlic (*Allium sativum* L.) is one of the main horticultural crops produced in the VIRC. The crop is sown in the region in late autumn and harvested in early summer, and as a result is invaded by AWS, SS, and AWS-SS weeds (D'Amico and Varela 2017). Considering the crop's limited competitive ability due to its slow and prolonged initial growth, upright architecture with minimal shading, and shallow, restricted root system, it becomes essential to employ an optimal management strategy to safeguard its yield from weed encroachment (Siddhu et al. 2018).

This study aimed to investigate the effects of replacing CT with 0T on floristic composition and weed emergence dynamics in a garlic crop, under the hypothesis that the implementation of a 0T system alters the weed community during the initial stage of operation. These changes in relation to various aspects of the life cycle of each species and potential management strategies were also analysed. This information helps to plan weed management strategies by reducing not only soil disturbance but also herbicide applications with their consequent ecological and economic impact.

MATERIALS AND METHODS

The VIRC has a semiarid temperate climate, with an average annual temperature of 15 °C and sandy loam-textured soils with 1% organic matter (Trillini et al. 2023). The average annual rainfall is around 500 mm with a significant water deficit condition; hence an adequate irrigation system is crucial to produce horticultural crops (Trillini et al. 2023). Two complementary experiments were carried out in an irrigated plot at the INTA-Ascasubi Experimental Station (39°23'31.8"S-62°37'43.8"W), Villarino, Buenos Aires province, Argentina (Figure 1). In these experiments, the floristic composition and weed emergence were quantified in a garlic crop planted under CT or 0T. Experiment 1 took place in 2017 where the emergence of AWS and AWS-SS weeds was counted, while experiment 2 was carried out in 2019 recording the emergence of SS and AWS-SS species.

Prior to each experiment, sowing of *Vicia villosa* Roth was carried out to homogenize the soil seed bank. For each experiment, a randomized complete block design with two treatments (0T and CT) and six replicates (N=12) was performed. Garlic seed-cloves were planted manually at the beginning of May following a spatial planting arrangement in two-sided furrows considering each furrow as a block (Figure 2). The planting density was 20 seed teeth per linear meter at a depth of approximately 8 cm. Garlic was fertilized twice with Urea, the first one manually (20 kg N ha^{-1}) and then by fertirrigation (125 kg N ha^{-1}). The irrigation system used was drip irrigation with tapes located between crop rows with emitters separated at 30 cm and with a delivery capacity of 1 L h^{-1}. During each experiment, and for each tillage system, gravimetric moisture (GM), air temperature and soil temperature at 5 cm depth were measured. GM was determined by weight difference in soil samples taken at 7 cm depth and placed in an oven (70 °C) until a constant weight was reached.

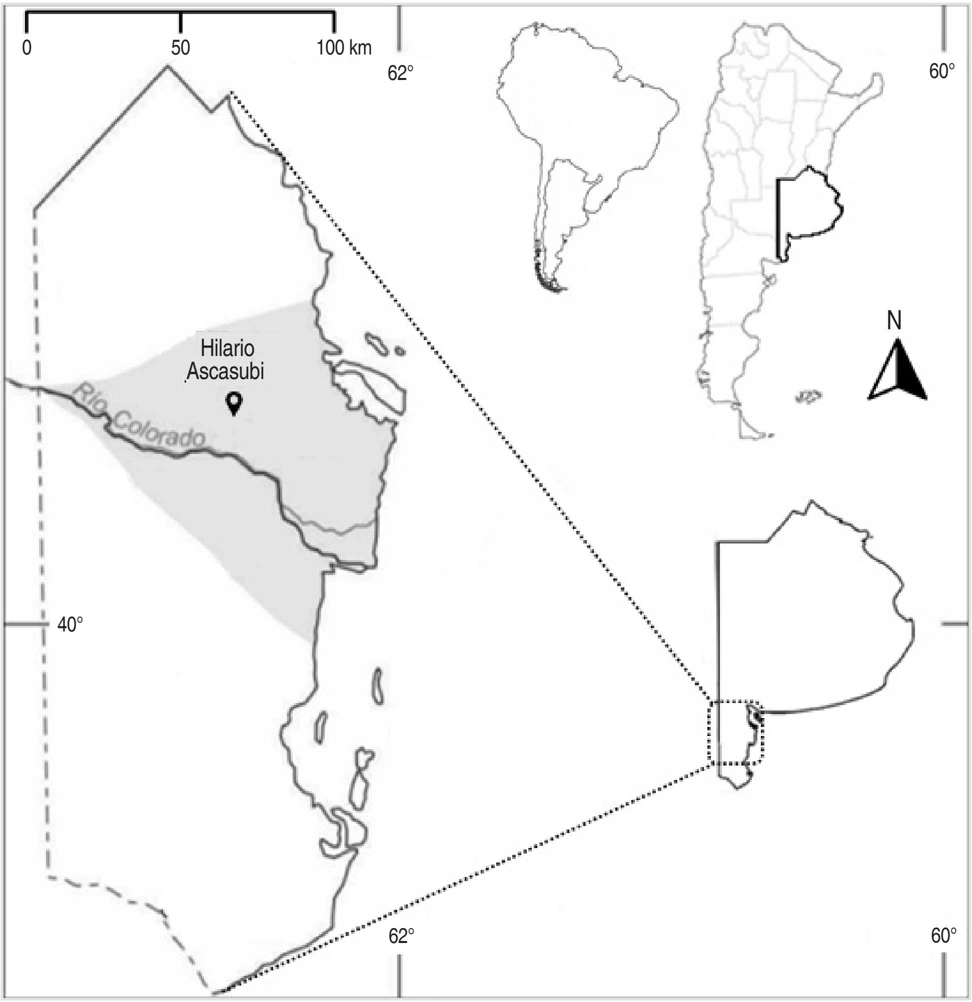

Figure 1. Location of Lower Colorado River Valley Irrigation District (Shaded area). Adapted from Torrez Gallardo (2019).

In both experiments, two quadrants of 0.25 m^2 were placed per plot where weed seedlings were counted and removed (Figure 2). This represented a typical sub-sampling design (Onofri et al. 2010). In experiment 1 the counting and removal of weed seedlings started in mid-winter and ended in mid-spring, while in experiment 2 it started in early spring and ended in early summer (Figures 5 and 6). For the 0T treatment, a chemical treatment with glyphosate was carried out at a rate of 0.83 kg Pa ha^{-1}. Under CT, weeds present prior to planting were mechanically removed by plowing the soil to a depth of 20 cm.

In each experiment, for each tillage system, weed species present were identified and density counted. A species was considered emerged when cotyledons were visible or, for perennial species, when the sprout measured more than 1 cm. Richness was calculated as the total number of species present. Density (seedlings m^{-2}) and relative frequency (%) of emerged seedlings of each species in each year and between tillage systems were analyzed with ANOVA followed by Tukey's test (*P*>0.05) using INFOSTAT® statistical software. When homoscedasticity and normality assumptions were not met, abundance data were previously square root transformed.

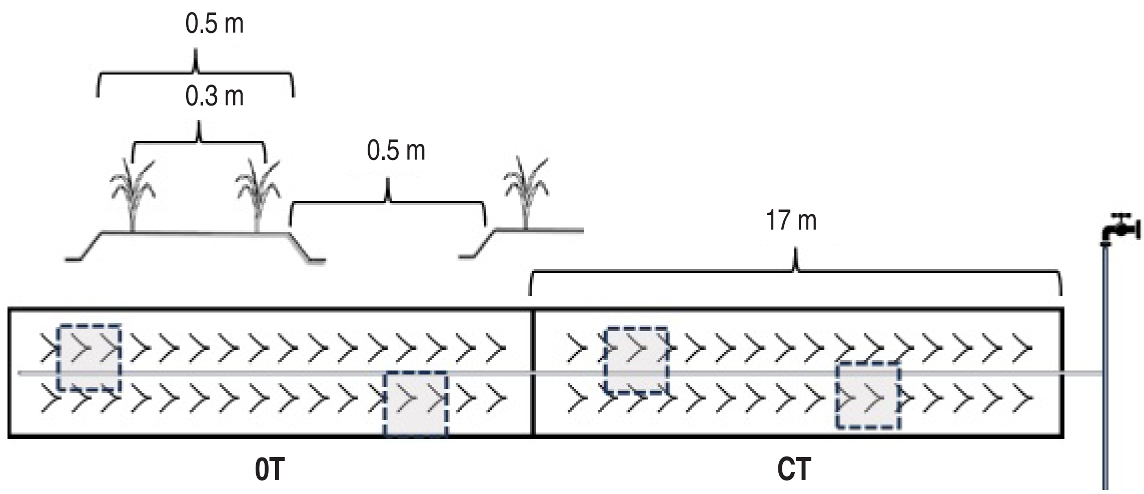

Figure 2. Schematic representation of the experiment. **Above:** garlic seed cloves planted according to a spatial planting arrangement in two-sided furrows, considering each furrow as a block. **Below:** one of the six blocks made in the experiments according to a randomized complete block design with two treatments (0T and CT) and six replicates (N=12). At the beginning of each experiment, two quadrants (sub-sampling) per plot were randomized established, and fixed, where the measurements were made.

To compare floristic composition for each year and for each tillage system, Simpson's index (Travlos et al. 2018) was calculated according to Equation (1):

$$D = 1 - \frac{\sum_{i-1}^{S} n_i(n_i - 1)}{N(N-1)} \quad (1)$$

Where S is the number of species present, n is the density of each species and N is the sum of the densities of all species.

To measure the similarity of species composition between tillage systems Jaccard's coefficient (Travlos et al. 2018) was applied according to Equation (2):

$$J = \frac{a}{a+b+c} \quad (2)$$

Where a is the total number of species present in both tillage systems, b is the number of species present only in LC, and c is the number of species only in L0.

RESULTS AND DISCUSSION

As shown in Figure 3, in experiment 1 under 0T soil temperature was on average 3 °C lower and GH 2% higher. Records were similarly repeated in experiment 2 (data not shown). In soils prepared for planting, lower temperature and higher moisture are normally cited in 0T systems relative to CT, primarily because plant residues remain on the surface (Tuesca et al. 2001).

Crop yields, in terms of bulb weight and size distribution, did not evidence differences between treatments (INTA-EEA Ascasubi personal communication), coinciding with previous trials (D'Amico and Varela 2017).

In both experiments, the total density of emerged weeds was higher under CT (*P*<0.05), being on average 386 (CT) and 239 (0T) seedlings m^{-2} in experiment 1 and 201 (CT) and 170 (0T) seedlings m^{-2} in experiment 2. There were mainly annual broadleaf species, varying the dominant weeds between experiments and between systems (Table 1). In experiment 1 the richness of AWS species was higher

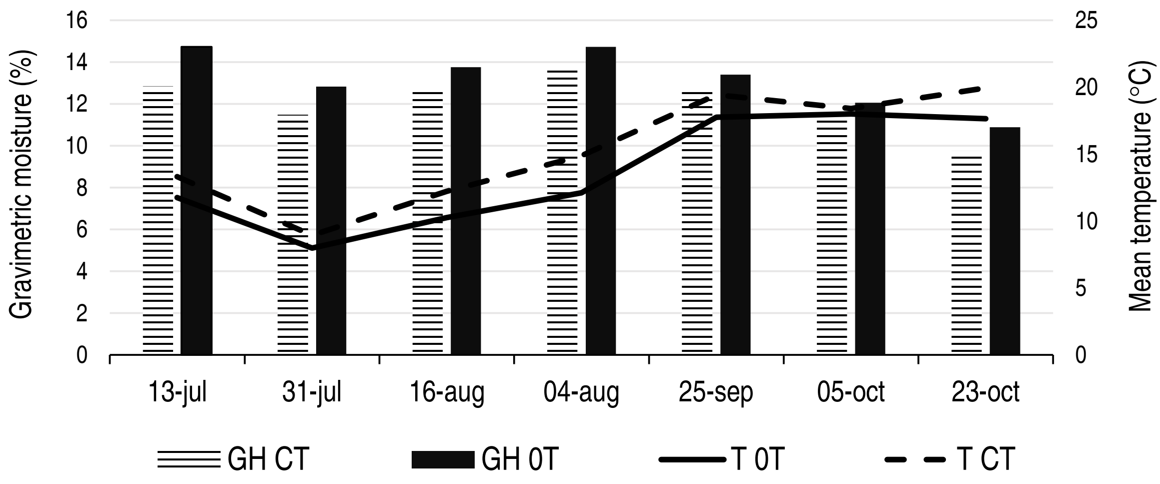

Figure 3. Gravimetric moisture (GH) and soil temperature (T) measured at 7 and 5 cm depth, respectively, for the no-till (L0) and conventional tillage (CT) treatments in experiment 1.

under CT than under 0T (18 and 13 species, respectively), while in experiment 2 both systems presented 18 SS and AWS-SS species. Values obtained by Simpson's index were 0.85 (CT) and 0.82 (0T) in experiment 1, and 0.79 (CT) and 0.80 (0T) in experiment 2. These values are relatively high and indicate a similar weed community diversity in all contexts, which was also observed by Alarcón et al. (2018) after a similar but long-term study. Jaccard's coefficient was 0.63 and 0.64 for experiments 1 and 2, respectively, suggesting that although both tillage systems showed a similar abundance structure in both experiments, weed communities varied by 36% in their species identity. This could be important in relation to weed management strategies, mainly because by varying the species composition, herbicides efficiency could be different.

Table 1. Relative frequency (%) of weeds in the garlic crop under conventional tillage (CT) or zero tillage (0T) for experiments 1 and 2.

Species		Experiment 1		Experiment 2	
		CT	0T	CT	0T
Amaranthus hybridus L.	annual SS	-	-	0.30	0.15
Ammi majus L.	annual AWS	1.30	0.42	-	-
Avena fatua L.	annual AWS	2.85	-	-	-
Centaurea calcitrapa L.	annual AWS	-	-	0.15	0.15
Chenopodium album L.	annual SS	3.89	1.67	1.95	4.13
Cichorium intybus L.	perennial AWS	-	-	0.15	-
*Cirsium vulgar*e (Savi) Ten.	annual AWS	-	0.42	0.50	-
Conyza bonariensis (L.) Cronquist	annual AWSS	15.29	33.47	-	12.95
Cynodon dactylon (L.) Pers.	perennial SS	0.26	-	2.72	1.89
Cyperus rotundus L.	perennial SS	-	-	-	0.63
Digitaria sanguinalis (L.) Scop.	annual SS	5.70	-	32.98	17.88
Diplotaxis tenuifolia (L.) DC.	perennial AWSS	3.11	5.02	24.57	30.21
Echinochloa crus-galli (L.) P. Beauv.	annual SS	-	-	4.25	5.44
Euphorbia serpens Kunth	annual SS	-	-	0.50	-
Gamochaeta filaginea (DC.) Cabrera	annual AWS	2.85	10.46	-	-

Table 1

Species		Experiment 1		Experiment 2	
		CT	0T	CT	0T
Hirschfeldia incana (L.) Lagr. Foss.	annual AWS	-	-	11.11	5.29
Lamium amplexicaule L.	annual AWS	0.78	2.09	0.30	0.44
Medicago sp.	annual AWS	0.52	-	-	-
Poligonum aviculare L.	annual AWS	0.78	0.84	-	-
Portulaca oleracea L.	annual SS	2.07	-	5.30	0.49
Raphanus sativus L.	annual AWS	24.35	8.37	1.36	0.83
Rapistrum rugosum (L.) All.	annual AWS	5.44	5.86	0.30	-
Rhaponticum repens (L.) Hidalgo	annual AWS	-	-	0.17	0.29
Rumex crispus L.	perennial AWS	0.26	-	-	0.29
Salsola kali L.	annual SS	-	-	-	0.49
Senecio vulgaris L.	annual AWS	0.52	2.93	1.21	0.15
Sonchus asper L.	annual AWS	-	-	-	1.60
Sonchus oleraceus L.	annual AWS	8.29	11.72	8.06	15.45
Tribulus terrestris L.	annual SS	-	-	0.55	0.29
Vicia villosa Roth	annual AWS	21.76	16.74	5.60	0.97
Total		100	100	100	100

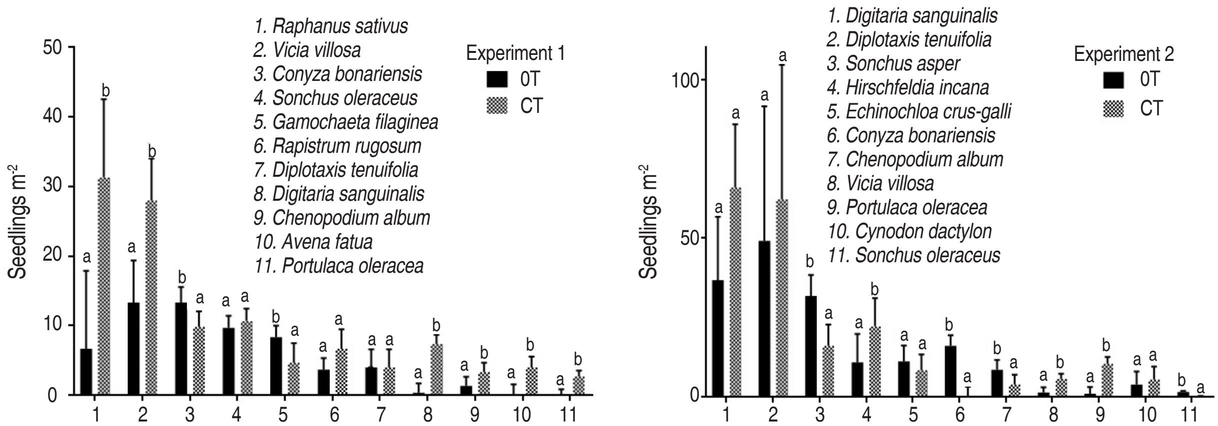

Figure 4. Density (seedlings m^{-2}) of weeds in experiments 1 and 2 under conventional tillage (CT) and no-tillage (0T). Different letters indicate differences in the density of a given species between tillage systems according to Tukey's test (P<0.05).

In experiment 1, 24.3% of the seedlings that emerged under CT belonged to *Raphanus sativus* and 33.5% under 0T to *Conyza bonariensis* (Table 1), a similar result was observed by D'Amico and Varela (2017) where the dominant species under CT was also a Brassicaceae (*Hirschfeldia incana*), and under 0T *C. bonariensis*. In experiment 2, mostly SS species were recorded, resulting dominants under CT *Digitaria sanguinalis* (33.0%) and under 0T *Diplotaxis tenuifolia* (35%).

As described by Zanin et al. (1997) and Tuesca et al. (2001), the consequences of the transition from CT to 0T involve treatments that lead to a repetitive re-colonization of niches generating a weed community composed mainly of anemophilous dispersal therophyte species. Likewise, in the present study, a higher abundance of *C. bonariensis* and *G. filagina* was observed under 0T (Table 1, Figure 4). These Asteraceae have small cypsela with hairy pappus that facilitates wind dispersal over long distances. Also, they fructify for a long period, and their seeds have low or no dormancy and an intermittent and prolonged emergence period, being imperative their control on roads and bordering lots to avoid their dispersal (Loura et al. 2020). In a conservationist system, as 0T, seed emergence of anemophilous species accumulated on the soil surface could be reduced by including strategic tillage or, when dealing with photoblastic species, by implementing mulching or cover crops that leave residues on the surface (Chauhan et al. 2006b, Loura et al. 2020).

Vicia villosa, *R. sativus*, *S. oleraceus*, *R. Rugosum*, among others, are AWS species that show in both tillage systems a main peak of emergence at the beginning of winter (Figure 5). In order to avoid production losses, autumn-winter peaks must be controlled, or they will strongly impact garlic crop growth and development (Siddhu et al. 2018). On the other hand, the control operation of SS seedlings, that emerged in late spring, such as *D. sanginalis* and *C. album* (Figure 6) will depend on the abundance and size of the plants, since they could hinder bulb harvesting (Siddhu et al. 2018). Thus, if no control measures are taken, species will complete their reproductive cycle, contributing to the seed bank and becoming a potential problem in future years (Fernández et al. 2014). This is important in contexts dominated by species with high reproductive potential and seeds that remain viable in the soil for years, such as *C. bonariensis* and *R. sativus* (Wu et al. 2007; Shrestha et al. 2008).

Weed in agroecosystems is defined as any plant that interferes with the use of crop resources (Fernández et al. 2014). *Vicia villosa* was considered as such in the present context, despite being a cultivated forage species. Thus, having been used as a predecessor crop and possessing high natural reseeding capacity, in experiment 1 it was one of the most abundant species during cultivation in both tillage systems (Table 1), presenting higher seedling recruitment under CT (P<0.05; Figure 4). Seed dormancy breaking of *V. villosa* occurs after a short post-dispersal after-ripening with the accumulation of 25 to 30 °Cd (degreedays) during summer emerging in autumn (Renzi et al. 2014). Therefore, after a vetch crop, a prolonged autumn fallow with high control pressure could be included in the rotation. Since vetch seedlings emerge from more than 10 cm deep (Renzi et al. 2014), if the fallow is mechanical, it may be necessary to supplement with chemical control.

The most abundant Brassicaceae found in this study were *R. sativus* and *R. rugosum* (Table 1). In experiment 1, *R. sativus* showed similar emergence patterns in both systems with a marked peak in early winter (Figure 5). However, three times higher emergence was recorded under CT (Figure 4; P=0.022), possibly because under 0T germination was inhibited by higher seed exposure to light and lower pericarp rupture in the absence of mechanical control (Vercellino et al. 2019). In experiment 2 the quantified emergence was almost null given that winter temperatures induce secondary dormancy in *R. sativus* (Vercellino et al. 2019; Table 1). On the contrary, in experiment 1 *R. rugosum* showed a differential behavior depending on the tillage system. Under 0T, two emergence peaks of similar magnitude were quantified: the first at the end of July and the second at the end of September; while under CT there was only one winter peak that doubled in magnitude the one observed in 0T (Figure 5). In both *R. sativus* and *R. rugosum*, the embryo presents nondeep physiological dormancy with germination being mechanically restrained by the silique (Manalil et al. 2018; Vercellino et al. 2019), so the fruit walls must be abraded for the radicle to pass through them. Naturally, a large proportion of the pericarp is physically, chemically, and/or biologically degraded during the summer. Thus, considering that tillage implements break the fruit in *Raphanus* spp. (Vercellino et al. 2019), the higher emergence observed under CT could be explained.

Hirschfeldia incana is also an AWS Brassicaceae, and then, the emergence peak recorded in spring in experiment 2 is due to its facultative behavior (Figure 6). This fact is feasible given that the optimal germination temperatures of *H. incana* range between 20 to 35 °C (Castro et al. 2016). In turn, a higher emergence was quantified under CT (P<0.05; Figure 4) possibly due to the rupture of fruit walls caused by mechanical tillage.

Unlike the Brassicaceae described above, *Diplotaxis tenuifolia* is a perennial SS species with dehiscent fruit and a wide distribution in the region under study (Vigna and Fernández 2018). Among other attributes, it has a high reproductive rate, vegetative propagation by gemmiferous roots, and high adaptability to the wide range of environmental conditions prevailing in the southern region of Buenos Aires province (Vigna and Fernández

2018). In experiment 2, a peak with a high number of weed emergences was recorded in *D. tenuifolia* towards the end of spring in both CT and 0T (Table 1; Figure 6), As *D. tenuifolia* is a perennial species, it is expected that over the years weed abundance will increase in 0T systems (Tuesca et al. 2001).

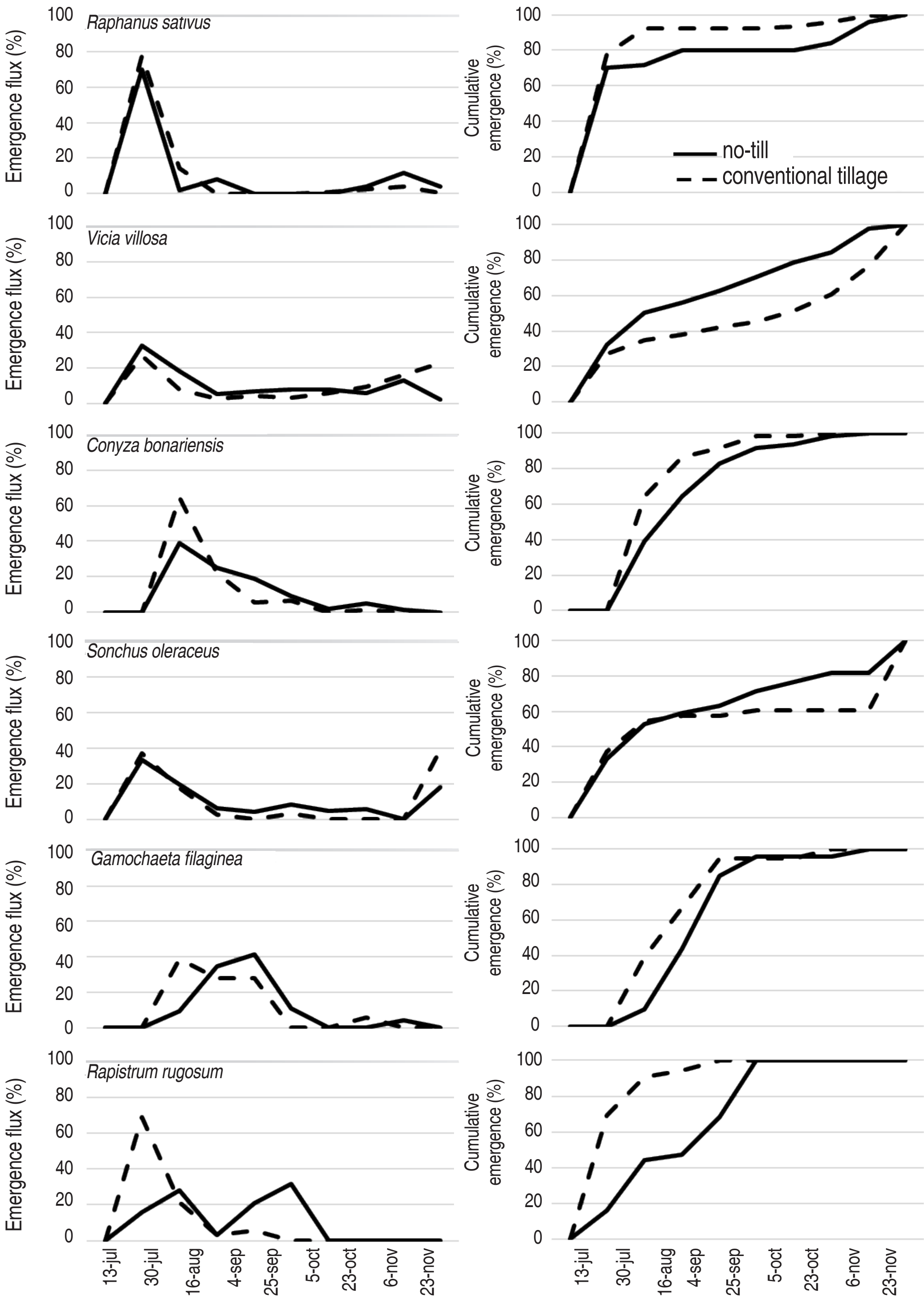

Figure 5. Percent emergence flux for each sampling date (left) and cumulative percent emergence (right) of the most abundant weeds under no-till and conventional tillage for experiment 1.

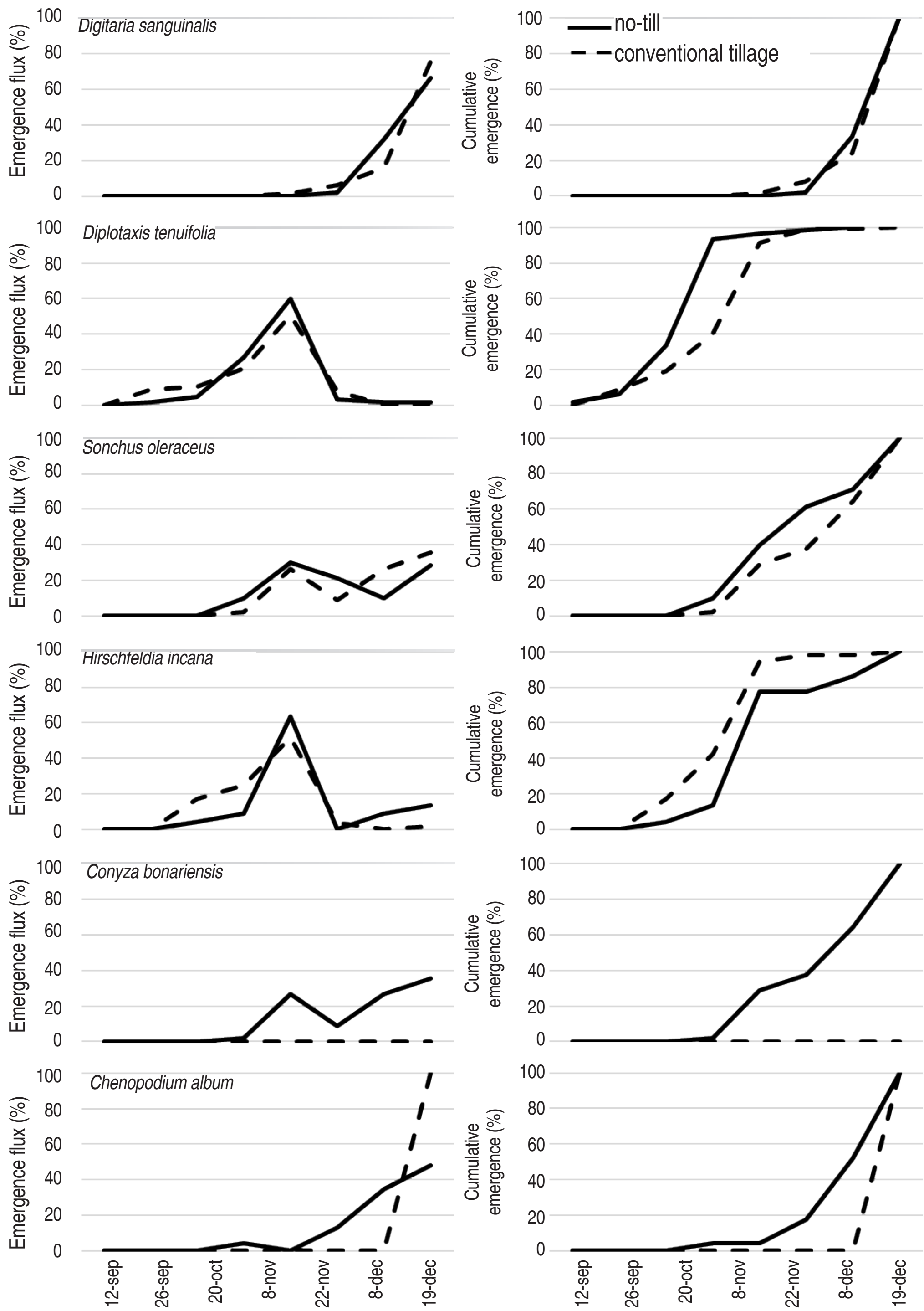

Figure 6. Percent emergence flux for each sampling date (left) and cumulative percent emergence (right) of the most abundant weeds under no-till and conventional tillage for experiment 2.

In both experiments, the most abundant Asteraceae were *C. bonariensis* and *S. oleraceus* showing similar emergence patterns throughout the garlic crop cycle, since they can germinate in a wide range of temperatures and water conditions (Chauhan et al. 2006b; Wu et al. 2007; Widderick et al. 2010). In experiment 1, they showed similar emergence patterns among systems (Figure 5; P>0.05). However, in experiment 2 there was a higher recruitment under 0T (Figure 4 and 6; P=0.0014) coinciding with Chauhan et al. (2006a). For both species, emergence is higher when seeds are near the soil surface, possibly due to their photoblastic character (Chauhan et al. 2006b; Wu et al. 2007; Widderick et al. 2010). Due to *S. oleraceus* seed viability is low on the soil surface, Widderick et al. (2010) hypothesize that under 0T if emergence flows are controlled for eight months without allowing plants to form seeds, the species will reduce its abundance drastically. On the other hand, strategic tillage could reduce emergence by affecting the vertical distribution of the seed bank in the soil. This would reduce light exposure and reduce the vigor of seedlings and their competitive ability (Chauhan et al. 2006a). In these cases, it would not be recommended to make new soil mechanical operations immediately so that the seeds do not return to the surface.

Chenopodium album is a troublesome weed in the area and showed opposite results between 0T and CT in both experiments (Table 1, Figure 4). In experiment 1, there was a greater number of seedlings under CT than 0T, as was also observed by Alarcón et al. (2018). In experiment 2, seedling density was greater than in experiment 1, given that seedling count continued until the beginning of summer, being the optimum period for emergence (Table 1). At the same time, seedling emergence under 0T was earlier in time (Figure 6), probably because seeds were spread shallow in the soil (Tang et al. 2022). An interesting situation was reported by Nikolić et al. (2021) who observed that in a dry spring, in the presence of abundant wheat stubble, the emergence of *C. album* was earlier than in bare soil but was reduced by 44%. Consequently, considering that most *C. album* seeds are photoblastic, it is recommended to ensure residue retention or coverage on the soil surface in no-tillage systems as a suitable management strategy for inhibiting its spread (Tang et al. 2022).

Digitaria sanguinalis is a SS species of high incidence in the study area. Although this species had a similar emergence flux under 0T and CT (Figure 6), it showed higher germination under CT (Figure 4). Seeds dispersed at the end of the summer usually have a high primary dormancy level which is released by low winter temperatures, especially under fluctuating soil temperatures (Oreja et al. 2017). The presence of stubble could reduce the fluctuating temperatures and light remaining reducing seedling emergence under 0T, as also was observed by Nikolić et al (2021). Nevertheless, this species shows a temporal seed bank under 0T where most seeds can survive on the soil surface for less than a year. Thus, to reduce *D. sanguinalis* population in no-till systems, diminishing the re-entry of new seeds in the soil could be a very effective strategy (Oreja et al. 2020).

The greater emergence of *P. oleracea* under CT (Figure 4) coincides with the findings of Tuesca et al. (2001), who argue that the conditions of greater light availability and temperature, typical of cultivated areas, would favor its germination and establishment. However, according to Khakzad et al. 2019, there should be less emergence under CT due to the small size of its seed which, being buried, could go into secondary dormancy or, in the case of germination, not have sufficient reserves to reach the surface.

Considering the fragility of the productive systems in the VIRN region and the need to optimize water resources, the implementation of conservation tillage is imperative, and it is important to know shifts in weed communities under these conditions. On the other hand, by having information on which weeds are expected to emerge, and at what time depending on the tillage system employed, farmers can plan appropriate control practices that can be implemented in a timely manner. This allows for more accurate and efficient management and consequently improving crop yield and quality.

By understanding the critical stages of weed emergence in horticultural crops, farmers can apply herbicides in a selective and targeted manner, thereby reducing the excessive use of chemicals and minimizing environmental impact. In addition, this information can help to schedule labor and machinery more efficiently, saving time and production costs.

CONCLUSIONS

The results concluded that there are important changes in the floristic composition and weed emergence patterns immediately after the implementation of 0T compared to CT, suggesting that the filtering pressures exerted by each tillage system favor certain weed species over others, depending on their functional traits. Results show that under 0T, anemophilous Asteraceae, such as *Conyza bonariensis* and *Sonchus oleraceus*, increase their presence, whereas under CT, Brassicaceae with indehiscent fruiting such as *Raphanus sativus* and *Rapistrum rugosum,* emerge in abundance.

With this is contributing to improving weed invasion predictive models, developing more sophisticated management strategies and designing new tools and techniques for weed control. This research also provides a scientific basis for better understanding weed-crop interference, which in turn can drive further research in the field of sustainable agriculture.

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