

## Weed competitive ability of faba bean (*Vicia faba*), pea (*Pisum sativum*), and vetch (*Vicia sativa*) crops under semi-arid conditions

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### Abstract

Agricultural practices must adapt to address new climatic conditions and the rising global demand for food. Among these practices, cultivating crops resilient to various stresses while maintaining productivity—such as annual legume crops—is essential. This study aims to assess the competitive interactions between legume crops and weeds. Field experiments were conducted using a Randomized Complete Block design with three replicates. Six weed treatments, representing the presence and absence of weeds (utilizing natural weed communities) were applied as the main plots for each of three-grain legumes: pea (*Pisum sativum*), faba bean (*Vicia faba*), and vetch (*Vicia sativa*), under semi-arid Mediterranean conditions. To evaluate the crops' competitive abilities, weed and crop biomass were collected at 3, 6, and 9 weeks after sowing (WAS). Additionally, pod yield was measured for each species to determine crop yield. The results indicated that faba bean exhibited the strongest growth competition, sowing: a) the smallest difference in final (9WAS) biomass between weedy and weed-free treatments compared to peas and vetch (30, 55, 57% reduction, respectively), and b) significant benefits in continuous removal of weeds in peas, vetch as compared to the no-benefits in such treatment in faba beans. In terms of yield tolerance to weed competition, peas demonstrated the greatest resilience, followed by faba beans and vetch (24, 38, 76% reduction, respectively). The timing of the manifestation of the crops' suppressive abilities varied: in peas and vetch, there was no measurable effect on growth due to the weed competition at the early and medium stages (at 3 and 6WAS) of crop development but only at the late stage (9WAS). Given the importance of grain legumes and the limited research on their competitive interactions with weeds, further studies are needed to promote more sustainable agricultural practices.

**Keywords:** competitive ability; faba bean; grain legumes; pea; vetch; weed control; yield tolerance

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## Introduction

As the effects of climate change intensify and the global human population is estimated to surpass 9 billion by 2050, agricultural practices must be found to face the groundbreaking rise in demand for food (National Research Council, 2015). There is an urgent need to select crops that can adapt properly to new climatical conditions and identify their farming practices (Papastylianou *et al.*, 2021). In this aspect, the appropriate crops must be resilient to various stresses and withhold productivity, food security, quality, and agricultural sustainability (Lammerts *et al.*, 2018). Annual grain legumes can arise as a suitable group of crops assuring environment-friendly agricultural practices and food security (Duc *et al.*, 2015). European Union (EU) has recently underlined the significance of grain legume crops by including them in most greening policy measures (Cernay *et al.*, 2015; Watson *et al.*, 2017).

Grain legumes are frequently characterized as climate-smart crops as they are adapted to a wide range of environmental conditions. Due to their cultivation mostly in marginal environments, they can experience a variety and intensity of biotic and abiotic stresses (Bahl, 2015). Moreover, they also play an important role in ecosystem services as they improve physical soil properties and enrich the soil with N reducing the overdependence on fertilizers (Naudin *et al.* 2010; Vályi-Nag *et al.*, 2021). These low-input crops are also a storehouse of protein, vitamins, and other nutritional components with a high dietary value for both human and animals' diet (Wang *et al.*, 2009; Burstin *et al.*, 2011; Marposa and Jideani, 2017). In the last ten years, legume production has been globally rising (FAOSTAT, 2020).

Among grain legumes, pea (*Pisum sativum* L.), faba bean (*Vicia faba*), and vetch (*Vicia sativa*) belong to the Fabaceae family (Foyer *et al.*, 2016) and are also cultivated across Europe. Pea is the second most important grain legume and one major green vegetable in the world. At present, it is mostly a spring crop in temperate regions, while in Mediterranean-type environments pea is sown in autumn (Rubiales *et al.*, 2009). Thanks to its flexibility, early ripening, and cold resistance, pea crop comes with a great distribution range (Zotikov and Borovlev, 2008). Faba bean (*Vicia faba*), the fourth most cultivated cool-season legume worldwide, is grown as a grain and green-manure legume (Fouad *et al.*, 2013). In addition to the high nutritional value of faba bean seeds, the crop is related to a reduced need for fertilizer input due to its significant efficiency in biological nitrogen fixation (Jensen *et al.*, 2010). It is characterized by an adaptive capacity to several climatic and soil conditions (Singh *et al.*, 2013), while it is more tolerant to frost than most other legume crops (Murray *et al.*, 1988). Vetch (*Vicia sativa* L.), another cool-season member of the Leguminosae family, has a climbing growth habit and contains high protein levels (Hadjichristodoulou, 1978). It is cultivated for biomass and seed production (Enneking, 1995).

Appropriate farming practices should also be investigated to successfully adapt grain legumes in low-input or organic cropping systems. Among them, weed management should be considered an essential agronomic practice, as weed infestation in grain legumes can provoke a yield reduction of more than 50 % (Frenda *et al.*, 2013; Abdallah *et al.*, 2021). A literature review highlights weed control's significant impact on agronomic and yield characteristics in these crops (Frenda *et al.*, 2013; Abdallah *et al.*, 2021; Juhasz *et al.*, 2023). In most legumes, it is well established that they have a weak competitive ability towards weeds (Wall *et al.*, 1991; Townley-Smith and Wright, 1994; McDonald, 2003), and weed presence in legume organic systems limit the N nutrition and grain yields (Corre-Hellou and Crozat, 2005). Since grain legume crops generally compete weakly against weeds, herbicide applications (mostly pre-emergent ones) could be used (Kopke and Nemecek, 2010). However, there is an urgent need to reduce the amounts and risks of herbicides in the EU and support organic farming systems thanks to their ecosystem services and the rising demand for organic food products (Place *et al.*, 2009).

In this context, searching for alternative non-chemical weeding solutions is very important (Melander *et al.*, 2005; Pannacci *et al.*, 2017). To identify these methods, it is essential to identify all necessary competitive

dimensions between grain legume crops and weeds. In general, competition between crops and weeds depends on site-specific factors, such as climatic conditions, management strategies, the composition of weed flora, weed density, and weed emergence time (Rajcan and Swanton, 2001). It is well established that a number of factors could modify the crop: weed interactions as follows: tillering capacity, crop height (Korres and Froud-Williams, 2002), leaf area (Seavers and Wright, 1999), type of growth such as upright, long stem, high biomass (Ross *et al.*, 2001), shading ability (Lemerle *et al.*, 2001), allelopathy (Seavers and Wright, 1999; Khanh *et al.*, 2005).

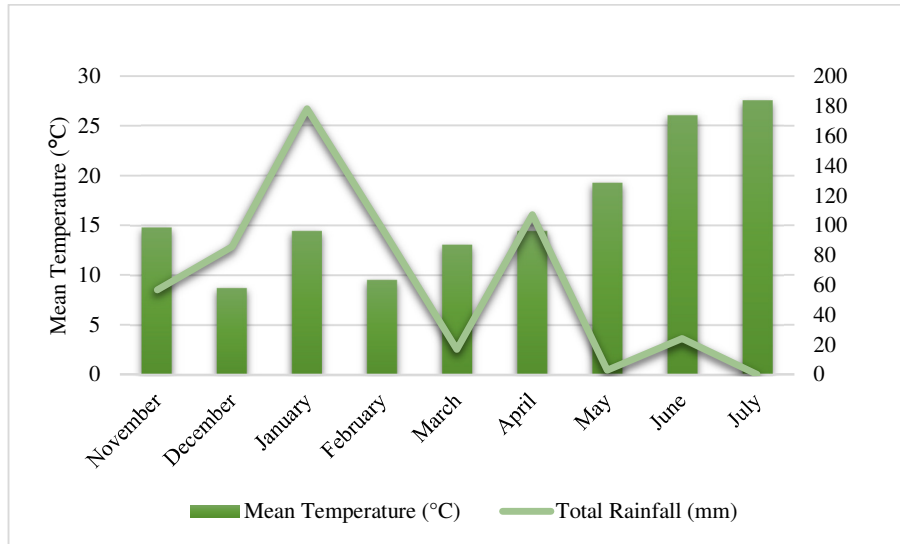
For major arable crops (i.e. cereals, soybeans), a large number of studies exist to measure the competitive ability of crop species and the association of crop competitive ability with specific morphological and crop-growth traits (Sardana *et al.*, 2017). However, few studies have reported the competitive ability of grain legumes under Mediterranean conditions and even fewer have examined more than one species. Additionally, most of the legume species are sown in late autumn or early winter to utilize the long growing period and the winter rainfall. However, in Greece, there are three farming scenarios that would benefit from a short-term legume crop sown in early spring and harvested in late June as follows: a) in areas whereas severe environmental conditions (mainly due to heavy and continuous rain) preventing optimum sowing dates like in western parts of the country (i.e. Iliia region); b) in the very northern parts of the country and some Aegean sea islands (i.e. Limnos) where legume spring sowing is common; and c) prolonged cultivation period in summer crops (i.e. in cotton) that eliminate the optimum window for autumn sowing.

The objectives of this study for the three-grain legumes were as follows: a) to measure their growth competitive ability, and b) to measure the yield tolerance to competition. Field trials were performed utilizing natural weed communities under semi-arid Mediterranean conditions.

## Materials and Methods

### *Experimental site*

A field study was conducted on the Agricultural University of Athens's experimental farm in the Spata region (southern Greece: latitude 37°58' N, longitude 23°54' E, altitude 123 m above sea level) from November 2018 to July 2019. The soil was sandy clay loam (sand 50%, clay 26%, and loam 24%) with a pH value of 7.9, organic matter 1.43 %, P-Olsen 59 mg kg<sup>-1</sup>, and CaCO<sub>3</sub> 3.9. Weather data were recorded daily from the meteorological station within 0.5 km of the experimental area. The climate in the site is characterized as typical semi-arid Mediterranean with cold winters, and hot summers, and historical mean rainfall during the crop-growing season is 346 mm. Rainfall, average, minimum, and maximum air temperature were reported as mean monthly data to highlight the conditions in whole year from November to July that includes the specific growing period of legume trials (Figure 1).



**Figure 1.** Monthly means of average air temperatures and total rainfall for the growing season from November 2018 to July 2019

*Plant material and experimental design*

Three different species of forage legumes, pea (*Pisum sativum*; cv. ‘Olympus’), faba bean (*Vicia faba*; cv. ‘Tanagra’), and vetch (*Vicia sativa*; cv. ‘Evinos’) that are widely grown in Greece were selected based on their wide adaptability and the high forage yield potential. The specific characteristics of the grain legume cultivars are as follows: cv. ‘Olympus’ is an early cultivar (Institute of Industrial and Fodder Plants, Larissa, Greece), cv. ‘Tanagra’ is a mid-late cultivar (Institute of Industrial and Fodder Plants, Larissa, Greece) and cv. ‘Evinos’ is an early cultivar (Agroland SA Company, Karditsa, Greece). They were evaluated in a Randomised Complete Block (RCB) design in a split-plot arrangement with three replications. For each species, the two weed treatments (presence and absence of weeds) were defined as the main plots, each divided into three subplots. The weed-free plots were kept by hand weeding, while the rest were subjected to the below treatments on a case-by-case basis and full description of the treatments are provided in Table 1. Every subplot was 2.5 m in length and 4 m in width with 0.25 m between rows. The total size of each plot was 90 m<sup>2</sup>. The seed rate of vetch crop was 160 kg per ha.

**Table 1.** The weed treatments applied in each subplot are 3, 6, and 9 weeks after sowing (WAS)

Weed treatments	3WAS	6WAS	9WAS
CP1	weeds	weeds	weeds
P2	weeds	no weeds	no weeds
P3	weeds	weeds	no weeds
CA1	no weeds	no weeds	no weeds
A2	no weeds	weeds	weeds
A3	no weeds	no weeds	weeds

CP1 and CA1 indicate the control plots for weeds' presence (continuous presence of weeds; P) and absence (continuous absence of weeds; A) during the whole cropping period. Regarding the presence treatments, for 3 WAS (P2), and 6WAS (P3), after that specific timing presence, weeds were removed (hand-hoeing) every 15 days up until the end of the cropping period. Regarding the absence treatments for 3WAS (A2) and 6WAS (A3), continuous removal (hand hoeing) for the specific timing and then weeds were left to grow until the end of the growing period.

*Crop management*

Seedbed preparation was conducted by plowing at a depth of 20 cm and followed by shallow tillage. Seeds of three species were sown separately by hand at a depth of 3 cm on the 4th of April to achieve the

recommended seed rate of 160 kg ha<sup>-1</sup> for faba bean, and 112 kg ha<sup>-1</sup> for pea and vetch. No basal fertilization or any disease and pest control practices were followed. Plants were rain-fed without any supplemental irrigation during the growing period. Several annual and perennial, grasses and broad-leaf weed species emerged, due to the available soil seed bank, a few days after plowing. Weeds were removed by hand hoeing, both at the corridors and the plots, depending on the WAS described above, according to the experiment's treatments (Table 1).

#### *Sampling and measurements*

For the determination of weed biomass, all above-ground weeds within the plots were cut to ground level with manual shears, at 3, 6, and 9 weeks after sowing (WAS). Then weeds were dried for 48 hours at 70 °C until their weight remained stable, and the weed dry weight was measured. As for the crop plants, three plants from each plot were collected each time that the weeds were removed (3, 6, and 9 WAS), and then overdried at 70 °C to record their dry weight. When crops reached the maturity stage BBCH: 99, on 2nd of July, the experimental subplots were hand-harvested. The harvested area was 10 m<sup>2</sup> per subplot. The pod yield was also estimated for each plant species for both the presence and absence of weed treatments.

#### *Statistical analysis*

All measured and derived data were subjected to Analysis of Variance (ANOVA), using the statistical software package Statgraphics Centurion XVI Version (Statgraphics Technologies, Inc., The Plains, Virginia). The estimation of the significance of differences among treatments was carried out by using Tukey's test at  $\alpha=5\%$  ( $p=0.05$ ). The tests of correlation coefficients and linear regression were calculated by the Statgraphics software to establish relationships between parameters.

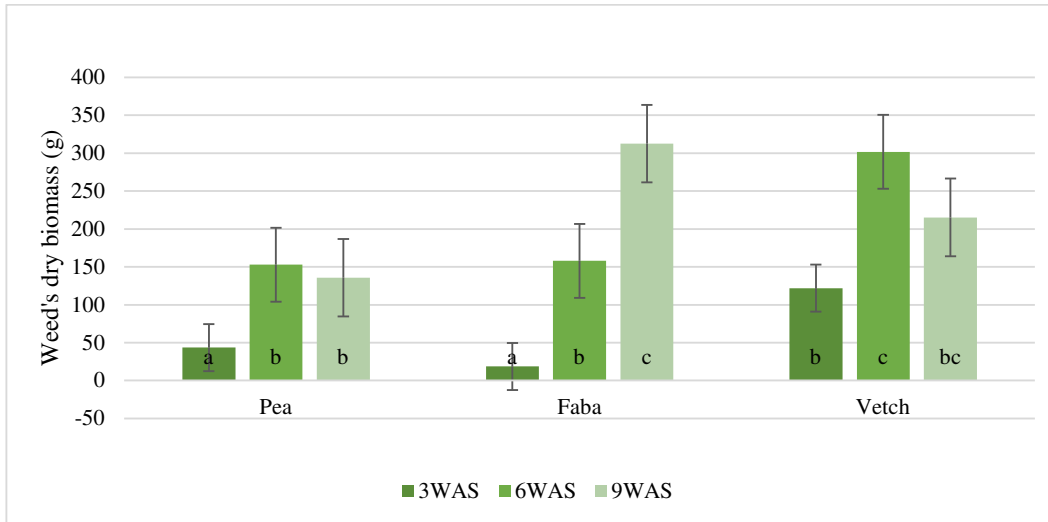
## **Results**

#### *Weed flora composition*

The weed flora associated with pea, faba bean, and vetch in the experimental field were identified. A total of 12 annual and perennial, grasses, and broadleaves weed species were recorded. Most of the weed species were annual broadleaved. It included, the major winter species such as: *Avena sterilis*, *Sonchus oleraceus*, *Papaver rhoeas*; spring species such as *Convolvulus arvensis* and *Malva sylvestris*. The above species were present in greater density (approximately 85% presence based on a visual scoring). Weed species identification also revealed the presence of *Sinapis alba*, *Glebionis coronaria*, *Calendula officinalis*, *Capsella bursa-pastoris*, *Stellaria media*, *Matricaria chamomilla*, and *Solanum elaeagnifolium* in much lower densities (less than 15% presence).

#### *Dry weed biomass*

A significant increase in weed biomass was observed from 3 to 9 weeks after sowing (WAS) for all three legume crops. In general, the lowest biomass values were recorded during the early period (3 WAS), and in peas compared to faba beans and vetch during the whole period (from 6 to 9WAS). At the early period (3WAS), the lowest weed biomass was measured in faba beans (18.5 g m<sup>-2</sup>; followed in peas (43.5 g m<sup>-2</sup>) and the highest in vetch (121,9 g m<sup>-2</sup>). In peas and vetch, there was no weed biomass increase from 6 to 9 WAS; however, in faba beans there was a continuous weed biomass increase that exceeded 300 g m<sup>-2</sup> (Figure 2).

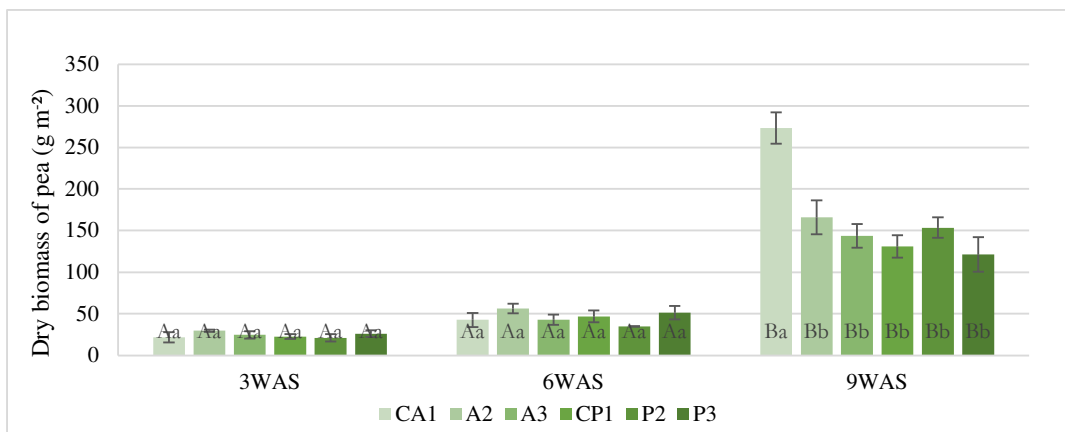


**Figure 2.** Weed dry biomass within the plots of pea, faba bean, and vetch plant crops at 3, 6, and 9 weeks after sowing (3, 6, and 9 WAS) for the 2019 growing season  
Values represent the total above-ground weed biomass, collected at the specific timings using the 0.5 × 0.5 m grid.

*Dry biomass of plant species*

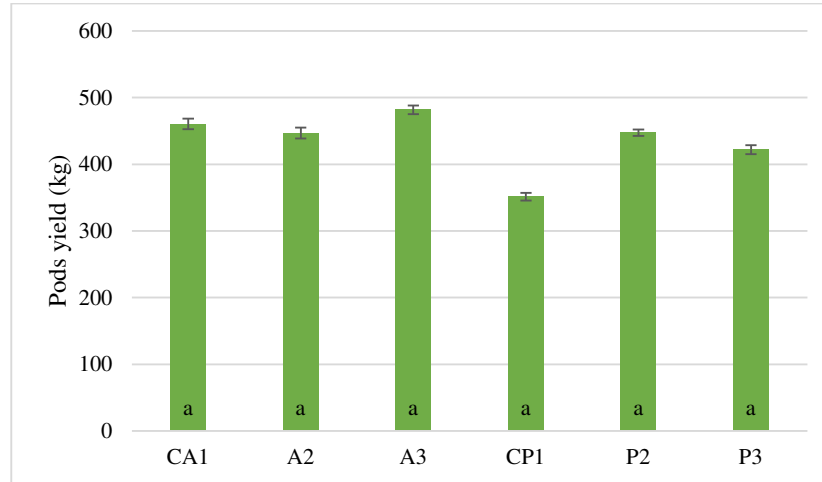
Pea (*Pisum sativum*)

According to the analysis of variance, the dry biomass of the above-ground part of the pea plants was affected by the weed treatments (Figure 3). At three weeks after sowing (3WAS), similar crop biomass was measured in all treatments (values ranged from 21.2 and 29.6 g m<sup>-2</sup>). At 6 WAS, an approximately 6% increase was recorded in pea biomass, while insignificant values were measured (from 34.8 to 56.4 g m<sup>-2</sup>) between all treatments. Finally, significant differences between plots with short term presence or absence of weeds were observed at 9 WAS. The maximum biomass value of 273.2 g m<sup>-2</sup> was measured in the prolonged weed absence treatment (CA1). All other treatments either representing the timing of weed presence or absence measured insignificant values (from 121.2 g m<sup>-2</sup> to 166 g m<sup>-2</sup>).



**Figure 3.** Dry biomass of pea plants after weed treatments at 3, 6, and 9 weeks after sowing (3, 6, and 9 WAS) for the 2019 growing season  
Vertical bars indicate the standard errors of the means. Values without a common letter are statistically significant according to LSD (0.05)

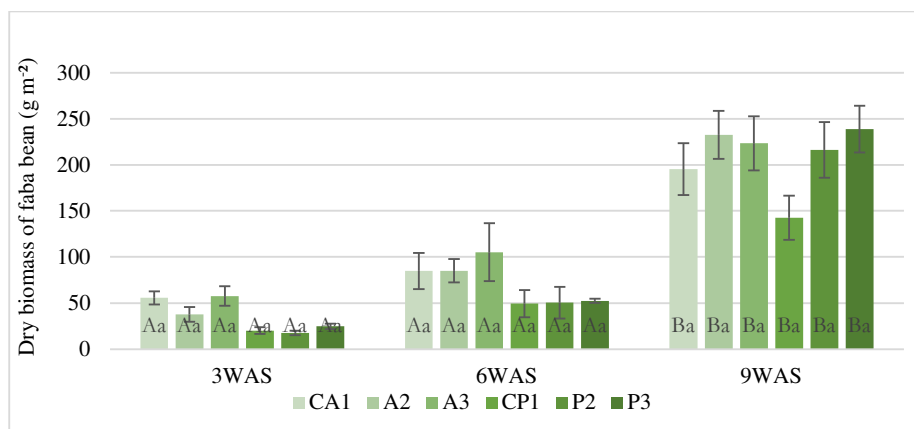
The weed flora affected negatively the yield of pea pods, which was not statistically significant in any of the six applied treatments. It was measured that continuous weed presence (CP1) reduced pod yields by 8% compared to the prolonged weed absence treatment (CA1). The highest pea pod yield of 481.63 kg per ha was recorded in the treatment of two period weed absence (A3), while insignificant values were measured (from 351.10 to 481.63 kg) between all treatments



**Figure 4.** The effects of the experimental factors on the pea pod yield in the 2019 growing season. Vertical bars indicate the standard errors of the means. All values are having a common letter showing that they are not statistically significant according to LSD (0.05).

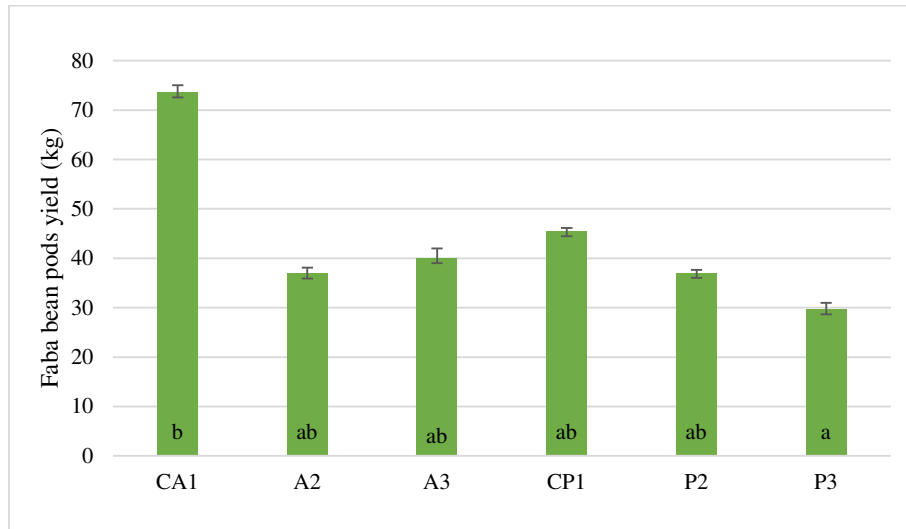
Faba bean (*Vicia faba*)

According to the analysis of variance, the dry biomass of the above-ground part of the faba bean plants was affected by the weed absence/presence treatments across the specific periods (3, 6, and 9 WAS) but not within each specific period ( $p < 0.05$ ) (Figure 5). At 3WAS, all treatments related to weed presence (CP1, P2, P3) reduced the crop biomass by 63% as compared to the ones with weed absence (CA1, A2, A3), although values were not statistically significant. At 6WAS, a similar trend as in 3WAS, in crop biomass was measured related to the weed presence/absence treatments. At 9WAS, the continuous weed presence (CP1) caused a biomass reduction of 27% compared to the weed-free control (CA1)



**Figure 5.** Dry biomass of faba bean plants after weed treatments at 3, 6, and 9 weeks after sowing (3, 6, and 9 WAS) for the 2019 growing season. Vertical bars indicate the standard errors of the means. Values without a common letter are statistically significant according to LSD (0.05).

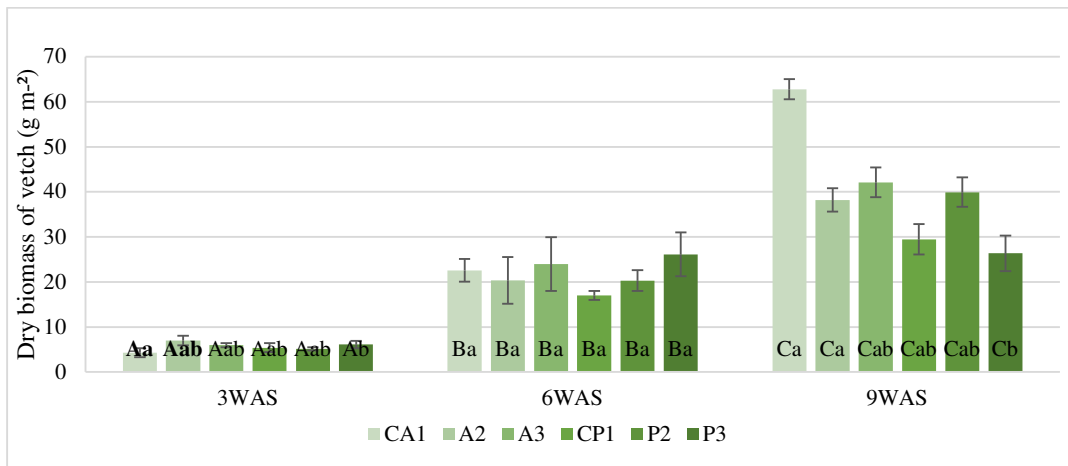
The weed flora reduced the pod yields of faba bean depending on the type of the treatment (Figure 6). As such, the continuous weed absence (CA1) resulted in the highest values (73.6 kg), whereas the continuous presence caused a decline in pod yields (45.4 Kg). All other treatments related to weed presence (P2, P3) and weed absence (A2, A3) had mostly similar values in pod yields.



**Figure 6.** The effects of the experimental factors on the faba bean pod yield in the 2019 growing season. Vertical bars indicate the standard errors of the means. Values without a common letter are statistically significant according to LSD (0.05)

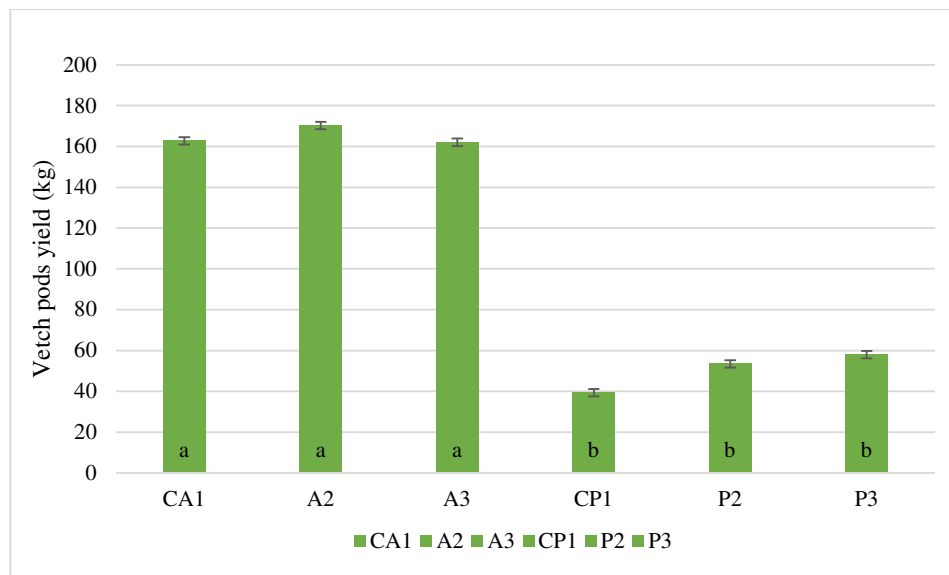
Vetch (*Vicia sativa*)

According to the analysis of variance, the dry biomass of the above-ground part of the faba bean plants was affected by the weed absence/presence treatments across the specific periods (3, 6, and 9 WAS) but mostly was similar within each specific period ( $p < 0.01$ ) (Figure 7). At 3WAS, similar biomass values were measured regardless of the specific weed presence (CP1, P2, P3) or absence (CA1, A2, A3) values. At 6WAS, a similar trend as in 3WAS, in crop biomass was measured related to the weed presence/absence treatments; the lowest value was measured at the continuous weed presence ( $16.9 \text{ g m}^{-2}$ ) (CP1). At 9WAS, the maximum plant biomass value of  $62.6 \text{ g m}^{-2}$  was recorded in the continuous weed absence treatment (CA1), whereas the continuous weed presence (CP1), P3 caused the lowest value (up to  $26.3 \text{ g m}^{-2}$ ). All other treatments related to weed absence (A2, A3) or weed presence (P2) had similar effect on crop biomass.



**Figure 7.** Dry biomass of vetch plants after weed treatments at 3, 6, and 9 weeks after sowing (3, 6, and 9 WAS) for the 2019 growing season  
Vertical bars indicate the standard errors of the means. Values without a common letter are statistically significant according to LSD (0.05)

Regarding the vetch pod yield, the weed flora reduced the pod yields of faba bean depending on the type of the treatment (Figure 8). As such, the continuous weed absence treatments (CA1, A2, A3) resulted in similarly high values (up to 170.2 kg), whereas the continuous presence treatments (CP1, P2, P3) caused a decline in pod yields (39.3 Kg).



**Figure 8.** The effects of the experimental factors on the vetch pod yield in the 2019 growing season  
Vertical bars indicate the standard errors of the means. Values without a common letter are statistically significant according to LSD (0.05).

### Discussion

The competitive ability of crops under natural occurring weeds refers mostly to the following two pillars, based on standard approaches as follows: a) the crop suppressive ability on weeds, which refers to low weed

growth and high crop growth during development, and b) the crop tolerance to weed competition refers to the ability of high yields under weed pressure.

For best results, crops (or even cultivars within each species) ideally manifest both the above attributes (i.e. being suppressive and tolerant at the same time); however, it is difficult to identify genotypes that possess both these attributes. Differences between suppressive ability and tolerance were reported in most crop cases such as: in wheat against *L. rigidum* Coleman *et al.* (2001); in soybeans against a range of weed species Bussan *et al.* (1997); in faba beans (Ghaouti *et al.* 2016); in vetch (Bilalis *et al.* 2009); in peas (Corre-Hellou *et al.* 2011).

#### *Growth competitive ability*

Regarding the growth competitive ability, the total growth suppressive ability is best visualized at the late stage of crop development (9WAS); differences at this crop development timing measures the relative growth competitive ability of the grain legume species. In this context, the faba bean was the most growth-competitive crop since it had the smallest difference in crop biomass between the weedy (CP1) and the weed-free (CA1) treatment; only a 30% reduction was recorded due to the weed presence (Figure 5). This result was further supported by the low benefit of removing the weeds from the plots (see A2 and A3 vs. CA1 treatments; Figure 5). Our results agree with previous reports showing the highly competitive ability of faba beans in Mediterranean conditions (Frenda *et al.*, 2013). As for pea and vetch crops, they showed a lower growth competitive ability than faba bean. An approximately 55% reduction was measured in crop biomass between the weedy (CP1) and the weed-free (CA1) treatments (Figure 3, Figure 7). Also, there was a significant benefit in removing the weeds even at a very early stage of crop development (see A2 and A3 vs. CA1 treatments; Figure 3, Figure 7). In peas, our results agree with previous reports showing low competitive ability against weeds, particularly at the beginning of the crop cycle (Hauggaard Nielsen *et al.*, 2001). Additionally, our results, are in agreement with a latest report regarding the high vulnerability of vetch to early weed competition (Juhasz *et al.*, 2023);

#### *Yield tolerance to competition*

Concerning the yield tolerance to competition, the presence of weeds (mostly regardless of their relative timing of presence) had a detrimental effect on yields as compared to the weed-free controls. More specifically, the presence of weeds (CP1) resulted in a reduction of 23.7%, 38.2%, and 75.8% in pea, faba bean, and vetch pod yield respectively compared to the weed-free control (CA1). Frenda *et al.* (2013) reported a mean yield reduction of 60% in faba bean when it was left to compete with wild mustard and Italian ryegrass as artificial weed species. In peas, various levels of yield losses due to weed competition were reported in the literature. In this context, Gargouri and Seely (1972) reported a 51% yield loss in a moderate wild oat presence; Wall *et al.* (1991) reported a 2 to 35% yield loss due to wild mustard; and Blackshaw and O'Donovan (1993) a 30 to 85% yield loss due to volunteer barley. In peas, our results are in agreement with a previous report indicating a high weed pressure affecting its growth due to slow crop establishment (shoot and root growth); however, from the flowering stage onwards the crop had a highly competitive ability mainly for light and therefore suffering from lower yield declines (Corre-Hellou 2011).

The grain legume species responded differently in terms of yields in the weed competition, as revealed by the rate of weedy (CP1) and the weed-free (CA1) treatments. The higher the rate of yield, the better competitor was the crop. The order was as follows: peas (0.76 g)>faba beans (0.38 g)>vetch (0.25 g). It is interesting to note that the most growth competitive species (i.e. faba beans) did not measure the same high yield tolerance to competition with weeds. In contrast, the other two low-growth competitive species showed a dichotomy characteristic; peas had the highest yield tolerance whereas vetch had the lowest yield tolerance. In the literature, it is documented that in yield tolerance to weed competition, all three (no/positive/negative) relationships exist. In faba beans, Ghaouti *et al.* (2016), reported a negative correlation whereas in other studies

a positive correlation was measured (Aqtbouz *et al.*, 2018). In peas, a variable yield decline was measured by weed competition up to 64% yield decline in the weedy control (Harker *et al.*, 2001).

#### *Timing of the suppressive ability*

Regarding the timing of the manifestation of the suppressive ability, it was interesting to note that in peas and vetch, there was no measurable effect on growth due to the weed competition at the early and medium stages (at 3 and 6WAS) of crop development but only at the late stage (9WAS), (see Figure 3, Figure 7). Peas are particularly vulnerable to lodging, highlighting that increased weed growth toward the end of the crop cycle may indeed be linked to the crop's sensitivity to lodging (Corre-Hellou *et al.* 2011). In previous reports, weed infestation poses a substantial challenge to faba bean cultivation, especially between 25 and 75 days after sowing, leading to potential yield reductions of up to 50% (Frenda *et al.*, 2013; Tawaha *et al.*, 2001). In peas, previous reports have documented a critical period of 40-60 days after sowing as the most important period for high susceptibility to weeds (Rana *et al.*, 2015). The timing is also related to the specific growth attributes of the field weed population; weeds with a high growth rate at early stages can gain an initial advantage, and small competitive advantages during growth early in the season can translate into large differences in size and light-interception ability later in the season (Corre-Hellou *et al.*, 2011). Understanding how soil conditions, particularly nitrogen (N) availability, influence the early growth of legumes and weeds is crucial for determining their competitive dynamics. Early growth phases are often a critical period for establishing dominance in competitive interactions, and differences in soil conditions can affect how crops and weeds grow and compete for resources.

#### *Crop attributes related to weed competitive ability*

Crop biomass is indeed a crucial factor in determining the competitive ability of crops against weeds. Our results that showed the highest weed competitive ability in faba beans, as compared with peas and vetch, agree with previous reports showing that differences in competitive ability between species are often linked to differences in biomass production (Mohler and Liebman, 1987; Poggio, 2005). It is logic to assume that crops that develop dense canopies and have rapid growth rates are often more successful in outcompeting weeds. Conversely, crops with lower biomass may struggle to compete, allowing weeds to thrive.

Another factor that is positively linked to weed competitive ability is the seed size (Storkey *et al.*, 2011). Vetch seeds are smaller (6-10 g/100 seeds) as compared to the larger seed species such as peas and faba beans (i.e. 18-25 g/100 seeds, 35-90 g/100 seeds, respectively; Abbo *et al.*, 2014) that generally agrees with our results.

Additionally, crop height was also positively linked to weed competitive ability; together with leaf characteristics such as leaf area and its vertical distribution in the plant shoot could affect competition for light (Caton *et al.*, 2001; Storkey *et al.*, 2011); that generally agrees with our results (higher weed competitive in faba beans).

Further studies should include a range of environments to capture how different conditions (e.g., soil type, climate, crop management practices) influence the competitive ability of the minor legume crops. This approach would not only help identify the most competitive varieties but also ensure that findings are reliable and applicable across a wide range of agricultural settings, enhancing the generalizability of the results. Such comprehensive research is essential for improving weed management strategies and optimizing crop production.

## **Conclusions**

Field trials were performed to measure the competitive ability of three-grain legume species (i.e. peas, faba beans, and vetch) against natural weed communities. The main weed species were *Avena sterilis*, *Sonchus*

*oleraceus*, and *Papaver rhoeas*, *Convolvulus arvensis* and *Malva sylvestris* (about 85% presence). Faba beans were the most growth competitive crop since they had the smallest difference in crop biomass between the weedy and the weed-free treatment as compared to peas and vetch. Regarding yield tolerance to weed competition, the following descending order was measured: pea>faba bean>vetch. The timing of the manifestation of the suppressive crop ability was variable in the three-grain legume crops, starting from the early timings in faba beans but only later on in peas and vetch. Grain legumes represent a valuable group of crops with limited research in all aspects of crop competition against the weeds, and to achieve greener agriculture further research should be a key priority. The study of competitive ability in plants is indeed complex, as natural weed populations vary across different locations and times. The main drivers of yield tolerance to competition, beyond the legume crop characteristics per se, are the following: a) the synchronous or asynchronous time of weed against the crop establishment, and b) the relative growth of the weeds against the crop plants. Additionally, the interaction between weeds and crops is not just a simple one-to-one relationship but is influenced by many factors, including the specific weed species, environmental conditions, and the crop variety itself.

When it comes to minor legumes (such as faba beans, peas, and vetch), there exist a number of local landraces, traditional varieties that would exhibit different competitive abilities when compared to more commercial cultivars of the main legumes (such as *Phaseolus* spp.) that have been bred for specific traits. To better understand these interactions, it would be important to investigate the competitive ability of those genotypes in various environments.

### **Authors' Contributions**

Conceptualization, D. C.; Data curation A. K. M.G.; Formal analysis A.K. M.G, A.P, E.A. D.C.; Funding acquisition E.A., D.C.; Investigation A.P., A.K., M.G; Methodology D.C.; Project administration A.P.; Resources, M.G.; Software A.K., M.G.; Supervision A.P.; Validation M.G.; Visualization A.K.; Writing - original draft A.K, A.P., D.C.; Writing - review and editing, A.K. D.C. All authors read and approved the final manuscript.

### **Ethical approval** (for researches involving animals or humans)

Not applicable.

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### **Conflict of Interests**

The authors declare that there are no conflicts of interest related to this article.

## References

- Abdallah IS, Abdelgawad KF, El-Mogy, MM, El-Sawy MBI, Mahmoud HA, Fahmy MAM (2021). Weed control, growth, nodulation, quality and storability of peas as affected by pre- and postemergence herbicides. *Horticulturae* 7:307. <https://doi.org/10.3390/horticulturae7090307>
- Afzal M, Shabbir G, Ilyas M, Jan SSA, Jan SA (2018) Impact of climate change on crop adaptation: Current challenges and future perspectives. *Pure and Applied Biology* 7:965-972. <http://dx.doi.org/10.19045/bspab.2018.700115>
- Aqtbouz N, Link W, Belqadi L, Ghaouti L (2018). Genetic diversity among North African faba bean landraces for competitive ability against weeds. *Journal fur Kulturpflanzen* 70:145-157. <https://doi.org/10.1399/JFK.2018.05.01>
- Bahl PN (2015). Climate change and pulses: approaches to combat its impact. *Agricultural Research* 4:103-108. <https://doi.org/10.1007/s40003-015-0163-9>
- Bilalis, D., Karkanis, A., & Efthimiadou, A. (2009). Effects of two legume crops, for organic green manure, on weed flora, under Mediterranean conditions: competitive ability of five winter season weed species. *African Journal of Agricultural Research* 4(12):1431-1441.
- Burstin J, Gallardo K, Mir RR, Varsheney RK, Duc G (2011). Improving protein content and nutrition quality. Book. *Biology and Breeding of Food Legumes*. <https://doi.org/10.1079/9781845937669.0314>
- Bussan AJ, Burnside OC, Orf JH, Ristau EA, Puettmann KJ (1997). Field evaluation of soybean (*Glycine max*) genotypes for weed competitiveness. *Weed Science* 45(1):31-37. <https://doi.org/10.1017/S0043174500092444>
- Caton BP, Mortimer AM, Foin TC, Hill JE, Gibson KD, Fischer AJ (2001). Weed shoot morphology effects on competitiveness for light in direct-seeded rice. *Weed Research* 41:155-163. <https://doi.org/10.1046/j.1365-3180.2001.00228.x>
- Cernay C, Ben-Ari T, Pelzer E, Meynard JM, Makowski D (2015). Estimating variability in grain legume yields across Europe and the Americas. *Scientific Reports* 5:1-11. <https://doi.org/10.1038/srep11171>
- Corre-Hellou G, Crozat Y (2005). N<sub>2</sub> fixation and N supply in organic pea (*Pisum sativum* L.) cropping systems as affected by weeds and pea weevil (*Sitona lineatus* L.). *European Journal of Agronomy* 22:449-458. <https://doi.org/10.1016/j.eja.2004.05.005>
- Corre-Hellou A, Dibet H, Hauggaard-Nielsen Y, Crozat M, Gooding P, Ambus C, ... Jensen ES (2011). The competitive ability of pea–barley intercrops against weeds and the interactions with crop productivity and soil N availability. *Field Crops Research* 122(3):264-272. <https://doi.org/10.1016/j.fcr.2011.04.004>
- Enneking D (1995). The toxicity of *Vicia* species and their utilisation as grain legumes. Centre for Legumes in Mediterranean Agriculture (CLIMA) Occasional Publication 6. Nedlands: CLIMA. <https://hdl.handle.net/2440/37799>
- FAOSTAT (2020). Food and Agriculture Organization of the United Nations. Statistics database.
- Fouad M, Mohammed N, Aladdin H, Ahmed A, Xuxiao Z, Shiyong B, Tao Y (2013). 5 – Faba Bean. In: Singh M, Upadhyaya HD, Bisht IS (Eds). *Genetic and Genomic Resources of Grain Legume Improvement*. London, Elsevier, pp 113-136. <https://doi.org/10.1016/B978-0-12-397935-3.00005-0>
- Foyer CH, Lam HM, Nguyen HT, Siddique KH, Varshney RK, Colmer TD, ... Considine MJ (2016). Neglecting legumes has compromised human health and sustainable food production. *Nature Plants* 2:16112. <https://doi.org/10.1038/nplants.2016.112>
- Frenda AS, Ruisi P, Saia S, Frangipane B, Di Miceli G, Amato G and Giambalvo D (2013). The critical period of weed control in faba bean and chickpea in Mediterranean areas. *Weed Science* 61(3):452-459. <https://doi.org/10.1614/WS-D-12-00137.1>
- Gargouri T, Seely CI (1972). Competition between spring peas and nine densities of wild oats (*Avena fatua*) plants. *Prog Rep West Soc Weed Sci* 102 -103
- Ghaouti L, Schierholt A & Link W (2016). Effect of competition between *Vicia faba* and *Camelina sativa* as a model weed in breeding for organic conditions. *Weed Research* 56(2):159-167. <https://doi.org/10.1111/wre.12193>
- Hadjichristodoulou A, Della A (1978). Factors affecting genotypic and environmental variance for crude protein content in cereals. *Euphytica* 27:117-126. <https://doi.org/10.1007/BF00039126>

- Harker KN (2001). Survey of yield losses due to weeds in Central Alberta. *Canadian Journal of Plant Science* 81:339-342. <https://doi.org/10.4141/P00-102>
- Hauggaard-Nielsen H, Ambus P, Jensen ES (2001). Interspecific competition, N use and interference with weeds in pea-barley intercropping. *Field Crops Research* 70(2):101-109. [https://doi.org/10.1016/S0378-4290\(01\)00126-5](https://doi.org/10.1016/S0378-4290(01)00126-5)
- Jensen E, Peoples MB, and Hauggaard-Nielsen H (2010). Faba bean in cropping systems. *Field Crops Research* 115:203-216. <https://doi.org/10.1016/j.fcr.2009.10.008>
- Juhasz C, Hadhazy A, Abido WAE, Pal V, Zsombik L (2023). Impact of some herbicides on the growth and the yield of common vetch (*Vicia sativa* L.). *Agronomy Research* 21:135-155. <http://dx.doi.org/10.15159/AR.23.028>
- Khanh TD, Chung MI, Xuan TD, Tawata S (2005). The exploitation of crop allelopathy in sustainable Agricultural production. *Journal of Agronomy and Crop Science* 191:172-184. <http://dx.doi.org/10.1111/j.1439-037X.2005.00172.x>
- Khanal AR, Mishra AK (2017). Enhancing food security: food crop portfolio choice in response to climatic risk in India. *Global Food Security* 12:22-30. <https://doi.org/10.1016/j.gfs.2016.12.003>
- Kole C, Muthamilarasan M, Henry R, Edwards D, Sharma R, Abberton M, ... Bryant J (2015). Application of genomics-assisted breeding for generation of climate resilient crops: Progress and prospects. *Frontiers in Plant Science* 6:563. <https://doi.org/10.3389/fpls.2015.00563>
- Köpke U, Nemecek T, (2010). Ecological services of faba bean. *Field Crops Research* 115:217-233. <https://doi.org/10.1016/j.fcr.2009.10.012>
- Korres NE, Froud-Williams RJ (2002). Effects of winter wheat cultivars and seed rate on the biological characteristics of naturally occurring weed flora. *Weed Research* 42:417-428. <https://doi.org/10.1046/j.1365-3180.2002.00302.x>
- Lammerts van Bueren ET, Struik PC, van Eekeren N, Nuijten E (2018). Towards resilience through systems-based plant breeding. A review. *Agronomy for Sustainable Development* 38:42. <https://doi.org/10.1007/s13593-018-0522-6>
- Lemerle D, Gill GS, Murphy CE, Walker SR, Cousens RD, Mokhtari S, ... Luckett DJ (2001). Genetic improvement and agronomy for enhanced wheat competitiveness with weeds. *Australian Journal of Agricultural Research* 52(5):527-548. <https://doi.org/10.1071/AR00056>
- Lemerle D, Verbeek B, Orchard B (2001). Ranking the ability of wheat varieties to compete with *Lolium rigidum*. *Weed Research* 41:197-209. <https://doi.org/10.1046/j.1365-3180.2001.00232.x>
- Melander B, Rasmussen IA, Bärberi P (2005). Integrating physical and cultural methods of weed control – examples from European research. *Weed Science* 53(3):369-381. <http://dx.doi.org/10.1614/WS-04-136R>
- Mcdonald GK (2003). Competitiveness against grass weeds in field pea genotypes. *Weed Research* 43:48-58. <https://doi.org/10.1046/j.1365-3180.2003.00316.x>
- Mohler CL, Liebman M (1987). Weed productivity and composition in sole crops and intercrops of barley and field pea. *Journal of Applied Ecology* 24:685-699.
- Murray GA, Eser D, Gusta LV, Eteve G (1988). Winterhardiness in pea, lentil, faba bean and chickpea. In: Summerfield, RJ (Ed). *World crops: Cool season food legumes*. Current Plant Science and Biotechnology in Agriculture. Springer, Dordrecht. [https://doi.org/10.1007/978-94-009-2764-3\\_66](https://doi.org/10.1007/978-94-009-2764-3_66)
- Lenka NK, Rattan L (2012) Soil-related constraints to the carbon dioxide fertilization effect. *Critical Reviews in Plant Sciences* 31:342-357. <https://doi.org/10.1080/07352689.2012.674461>
- National Research Council, Division on Earth, Life Studies, Board on Atmospheric Sciences, Climate Research Committee, & Committee on Radiative Forcing Effects on Climate (2005). *Radiative forcing of climate change: Expanding the concept and addressing uncertainties*. National Academies Press.
- Naudin C, Corre-Hellou G, Pineau S, Crozat Y, Jeuffroy MH (2010). The effect of various dynamics of N availability on winter pea-wheat intercrops: Crop growth, N partitioning and symbiotic N<sub>2</sub> fixation. *Field Crops Research* 119:2-11. <https://doi.org/10.1016/j.fcr.2010.06.002>
- O'Donovan JT, Blackshaw RE (1997). Effect of volunteer barley (*Hordeum vulgare* L.) interference on field pea (*Pisum sativum* L.) yield and profitability. *Weed Science* 45(2):249-255. <https://doi.org/10.1017/S0043174500092791>
- Pannacci E, Lattanzi B, Tei F (2017). Non-chemical weed management strategies in minor crops: A review. *Crop Protection* 96:44-58. <https://doi.org/10.1016/j.cropro.2017.01.012>
- Papastylianou P, Vlachostergios DN, Dordas C, Tigka E, Papakaloudis P, Kargiotidou A, ... Kousta A (2021). Genotype × environment interaction analysis of faba bean (*Vicia faba* L.) for biomass and seed yield across different environments. *Sustainability* 13:2586. <https://doi.org/10.3390/su13052586>

- Place F, Roothaert R, Maina L, Franzel S, Sinja J, and Wanjiku J (2009). The impact of fodder shrubs on milk production and income among smallholder dairy farmers in East Africa and the role of research undertaken by the World Agroforestry Centre. Occasional Paper 12. World Agroforestry Centre. <https://cgspace.cgiar.org/server/api/core/bitstreams/8f26d445-d247-41b4-82d9-20ffafe11dc2/content>
- Poggio SL (2005). Structure of weed communities occurring in monoculture and intercropping of field pea and barley. Agriculture, Ecosystems & Environment 109:48-58. <https://doi.org/10.1016/j.agee.2005.02.019>
- Rajcan I, Swanton CJ (2001). Understanding maize–weed competition: resource competition, light quality and the whole plant. Field Crops Research 71(2):139-150. [https://doi.org/10.1016/S0378-4290\(01\)00159-9](https://doi.org/10.1016/S0378-4290(01)00159-9)
- Rana SC, Pandita VK, Chhokar RS, Sirohi S (2015). Effect of pre and post emergence herbicides on weeds and seed yield of garden pea. Legume Research 38:484-487. <https://doi.org/10.5958/0976-0571.2015.00132.0>
- Rosenzweig C, Hillel D (1995). Potential impact of climate change on agriculture and world food supply. Consequences 1:23-32.
- Ross SM, King GR, Izaurralde RC, O’ Donovan JT (2001). Weed suppression by several clover species. Agronomy Journal 93:820-827. <http://dx.doi.org/10.2134/agronj2001.934820x>
- Roy DN, Sabri MI, Kayton RJ and Spencer PS (1996).  $\beta$ -cyano-L-alanine toxicity: Evidence for the involvement of an excitotoxic mechanism. Nature Toxins 4:247-253. [https://doi.org/10.1002/\(SICI\)\(1996\)4:6<247::AID-NTI>3.0.CO;2-M](https://doi.org/10.1002/(SICI)(1996)4:6<247::AID-NTI>3.0.CO;2-M)
- Rubiales D, Fernández-Aparicio M, Moral A, Barilli E, Sillero JC, Fondevilla S (2009). Disease resistance in pea (*Pisum sativum* L.) types for autumn sowings in Mediterranean environments - a review. Czech Journal of Genetics and Plant Breeding 45:135-142. <http://hdl.handle.net/10261/159865>
- Sardana V, Mahajan G, Jabran K, Chauhan BS (2017). Role of competition in managing weeds: An introduction to the special issue, Crop Protection, Volume 95. <https://doi.org/10.1016/j.cropro.2016.09.011>
- Seavers GP, Wright KJ (1999). Crop canopy development and structure influence weed suppression. Weed Research 39:319-328. <https://doi.org/10.1046/j.1365-3180.1999.00148.x>
- Abbo S, van-Oss RP, Gopher A, Saranga Y, Ofner I, Peleg Z (2014). Plant domestication versus crop evolution: a conceptual framework for cereals and grain legumes. Trends in Plant Science 19(6):351-360.
- Singh AK, Bharati RC, Manibhushan NC, Pedpati A (2013). An assessment of faba bean (*Vicia faba* L.) current status and future prospect. African Journal of Agricultural Research 8:6634-6641. <https://doi.org/10.5897/AJAR2013.7335>
- Singh AK, Bhat BP, Sundaram PK, Gupta AK, Singh D (2013). Planting geometry to optimize growth and productivity faba bean (*Vicia faba* L.) and soil fertility. Journal of Environmental Biology 34 (1):117-122.
- Tawaha AM, Turk MA (2001). Crop-weed competition studies in faba bean (*Vicia faba* L.) under rainfed conditions. Acta Agronomica Hungarica 49:299-303. <https://doi.org/10.1556/AAgr.49.2001.3.11>
- Townley-Smith L, Wright AT (1994). Field pea cultivar and weed response to crop seed rate in western Canada. Canadian Journal of Plant Science 76:907-914. <https://doi.org/10.4141/cjps94-074>
- Vályi Nagy M, Tar M, Irmes K, Rácz A, Kristó I (2021). Az őszi borsó hatása az őszi búza termésmennyiségére és fehérje hozamára együtt vetési kísérletben. Acta Agronomica Óváriensis 15:159-173. [https://epa.oszk.hu/03100/03114/00032/pdf/EP\\_A03114](https://epa.oszk.hu/03100/03114/00032/pdf/EP_A03114)
- Wall D, Friesen GH, Bhati TK (1991). Wild mustard interference in traditional and semi-leafless field peas. Canadian Journal of Plant Science 71:473-480.
- Wall DA (1992). Flurtagone for wild mustard (*Sinapis arvensis*) control in canola (*Brassica napus* and *B. campestris*). Weed Technology 6(4):878-883. <https://doi.org/10.1017/S0890037X00036411>
- Watson CA, Reckling M, Preissel S, Bachinger J, Bergkvist G, Kuhlman T, Lindström K, ... Vanhatalo A (2017). Grain legume production and use in European agricultural systems. Advances in Agronomy 144:235-303. <https://doi.org/10.1016/bs.agron.2017.03.003>
- White P, Harries M, Seymour M, Burgess P (2005). Producing pulses in the northern agricultural region. Kensington: Western Australia Department of Agriculture and Food. Perth. Bulletin 4656. <https://library.dpird.wa.gov.au/bulletins/153>
- Zotikov VN, Borovlev AA (2008). Improving the sustainability of crop production in modern conditions. Eagle 36-49.



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