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ALLELOPATHIC POTENTIAL OF LAMBSQUARTER AND FIELD BINDWEED SUPPRESSED THE GROWTH, YIELD AND ANTIOXIDANT ACTIVITY OF CAMELINA

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Allelopathic effect of lambsquarter (*Chenopodium album* L.) and field bindweed (*Convolvulus arvensis* L.) on germination and initial development of *Camelina sativa* by using leaves, stem, whole plant aqueous extracts and soil incorporated weed residues was studied in petri dish and pot bioassay. In petri dish bioassay, different concentrations (2.5%, 5%, 7.5%, and 10%) of aqueous extracts of stem, leaves and whole plant of both weed species were applied on camelina seeds. Among these, 10% whole plant extracts had shown a significant reduction in seed germination and initial growth of camelina. Moreover, weed residues incorporated in soil had inhibitory effect on growth and yield contributing attributes of camelina. Comparatively larger amount of various phenolic acids was determined in whole plant extracts of both weeds by GC-MS. Hence, the results revealed that *C. album* and *C. arvensis* are rich source of phenolic acids that greatly inhibited antioxidant activity which ultimately adversely affected the germination; seedling development and seed yield of camelina.
Keywords: Germination percentage, weeds extract, phenolic acid, catalase, superoxide dismutase.

INTRODUCTION

Camelina (*Camelina sativa* L.), also known as false flax, is a spring-planted annual crop that belongs to *Brassicaceae* family. It is low-input, high yield, drought and frost tolerant oilseed crop that suitably fits for dry land cultivation systems (Zanetti *et al.*, 2013). Camelina oil has exceptionally high fatty acid profile (90% unsaturated fatty acids and 30-40% α-linolenic acid), natural antioxidants, minimal glucosinolates & erucic acid and amino acids, that is well suited to human nutrition, industry and cosmetics (Yuan and Li, 2020). Although camelina plants showed highly tolerance to abiotic stresses, however, it is extremely susceptible to the soil heavily infested with strongly competing weeds like *Chenopodium album*, *Agropyronrepens*, *Matricariainodora* and *Cirsium arvense* etc (Waraich *et al.*, 2015).

As weeds have high competitive potential of acclimatization to the environment, not only there is competition between the crop and various weeds for nutrients, water, air, light and space but this competition also releases different types of allelochemicals which affect the germination and crop yield (Kakar *et al*., 2016). The weeds in nature release various toxic compounds in the environment while protecting themselves from the enemy. They use this allelopathic mechanism as s competitive strategy to suppress the growth of crop resulting into availability of resources to available for themselves (Velayati *et al*., 2011). The allelochemicals are released from different parts of plant in the form of volatilization, leachates from leaf during rain or dew formation and reach to the surface of soil beneath the plant canopy (Cerrudo *et al.*, 2012; Wandscheer and Rizzardi, 2013). Among different weeds, lambsquarters (*Chenopodium album*) is a noxious annual weed belongs to *amaranthaceae* family, abundantly occupies the cultivated fields of Pakistan. It articulates quick and robust invasion because of its outstanding genetic vigor, rapid growing behavior, adaptability towards wide range of climatic conditions, higher reproductive (~24,000 seeds per plant), competitive and even phytotoxic potential. Lambsquarters also releases allelochemicals in the environment and suppress growth of maize and other crop plants in the vicinity (Kakar *et al*., 2016).

In addition to lambsquarters, field bindweed (*Convolvulus arvensis*) is also one of the world ten dangerous weeds that replicates itself in a wide range of soil and environmental conditions (Yarnia, 2010). Its deep and extensive root system, together with its long-lasting seed bank, is a key feature to the noxious weed status that it receives worldwide. Field bindweed plants covers and suffocates immature seedlings and significantly reduced the growth and productivity of pepper (Karkanis *et al*., 2012). Literature reveals that, the presence of different quantities of field bindweed residues (10-100 gm^{-2}) in soil imparts different inhibitory effects i.e. 19.2-98.7% on root growth, 4.2-73.2% on seed germination and 44-72% on shoot growth of wheat (Soltys *et al*., 2013). Also due to its rapid climbing and clinching nature, it reduces germination rate and seedling growth leading to yield loss up

to 20-70% might be due to the presence of several phytotoxins in weeds (Culhavi and Manea, 2011).These phytotoxins vary in relative amount, chemical composition and distribution in various plant tissues depending upon different environmental conditions (Karkanis *et al*., 2012). Keeping in view the importance of weed management and problems of lambsquarters and field bindweed in different crops, the present study was planned and conducted to explore the role of allelopathic potential of lambsquarters and field bindweed on germination and productivity of camelina.

MATERIALS AND METHODS

A petri dish and pot experiment was conducted to explore the role of phenolic acids and antioxidant activities of lamsquarters and field bindweed in suppressing the growth and productivity of camelina at research area of University College of Agriculture and Environmental Sciences, The Islamia University of Bahawalpur, Bahawalpur (27° 42′ and 29° 45′ North and 69° 52′ and 73° 05′) (Pakistan) during winter (November-March) 2015-16.

***Petri dish bioassay*:** Fresh leaves, stems and whole plants of field bindweed and lambsquarter weeds were separated; thorns or any visible dirt were removed, washed with distilled water and dehydrated for seven days at room temperature (25±2°C) and used to prepare various aqueous extracts concentrations (2.5%, 5%, 7.5%, 10%) of stem, leaves and whole plant of lambsquarter and field bindweed. The fine desiccated plants were divided into stems and leave and diced into about 5cm pieces each. Various aqueous extract concentrations (2.5%, 5%, 7.5%, 10%) of stem, leaves and whole plant of lambsquarter and field bindweed were prepared. Distilled water was used as a control. The experiment was laid out in a Completely Randomized Design (CRD) with three replications. Randomly selected 10 healthy seeds of Camelina were disinfected with 5% H_2SO_4 solution for five minutes. These sterilized seeds were placed uniformly on wattman filter paper 10 in petri plates with 9 cm diameter. According to the treatments 3 ml aqueous extract of various concentrations were used to moisten the filter paper.

***Pot experiment*:** To investigate the allelopathic potential of lambsquarters and field bindweed, a pot experiment was conducted in wire house. Whole plants of lambsquarters and field bindweed were dried under shade and chopped into 5cm pieces. Experimental treatments comprised of incorporation of lambsquarter and field bindweed at the time of sowing (LD_0 and FD_0), 15 days before sowing (LD_{15} and FD_{15}) and 30 days before sowing (LD_{30} and FD_{30}) including control. These chopped plant materials were incorporated in soil of each pot at the rate of 2% (2% of soil weight, w/w ratio). Ten seeds of Camelina were sown in each pot. While the pot containing Camelina seeds without weeds residue was taken as control. The field capacity was determined by the gravimetric method, which consists on the difference between the wet soil after saturation and free drainage, and the weight of the dry soil. Daily weighing of the pots replacing the water lost.

The experiment was laid out in a CRD with three replications. Nitrogen fertilizer was applied at the rate of 360 mg per pot in two equal splits i.e. at the time of sowing and peak flowering. However, phosphorus and potassium fertilizers were applied at the rate of 180 and 136 mg per pot, respectively at the time of sowing. Plants were harvested manually and sun dried for two days and then threshed manually to record the various yield and yield contributing attributes.

***Growth attributes*:** Final germination percentage was calculated as the ratio of the number of seeds germinated to the total number of seeds sown, represented as %age.

Final germination percentage =Germinated seeds/ total seeds x 100

Mean germination time was calculated according to the equation given by Ellis and Roberts (1981).

Mean germination = $(\sum Dn)/(\sum n)$

Where D is the number of days counted from the start of the emergence and the number of seeds that had germinated on day D is expressed by n.

While 50% germination (T_{50}) time was executed by the formula of Farooq *et al*. (2011).

50% germination = ti + (N/2 - ni)

Where ni, nj cumulative number of seeds germinated by adjoining add up at times ti and tj when ni< N/2<nj and N is final number of germinated seeds.

The germination index was calculated by the equations described by Zhang *et al*. (2007).

Germination index =Xi/Yi+ Xii/Yii……. Xn/Yn

Whereas, X = number of seeds emerged for the day, Y = number of days from the first seed emerged, i, ii,……..n= number of days.

Germination energy was calculated according to the procedure adopted by Bam *et al.*(2006).

Germination energy (%)= Germinated seeds at 4 DAS/ total seeds x 100

The shoot length was measured after 10 days of germination with transparent meter rule. Fresh and dry weight of seedling was measured on a sensitive electronic weighing balance (model: SKU 833085). Seed vigor index was calculated by the equation given by Kaya *et al*. (2008).

VI=S×Σ (Gt/Dt)

where S is seedling height of the seventh day, Gt is number of germinated seeds in the "t th" day, Dt is number of days from the first day to the "t th" day.

Leaf chlorophyll contents were noted by using the method of Teng *et al*. (2004) with the help of chlorophyll meter (SPAD) (CL-01, Hansatech Instruments Ltd. UK). Leaf area index was calculated by following the method of Sestak *et al*. (1971). Plant height, no. of pods per plant, seeds per pod,

biological and economic yield was determined by using standard procedures.

***Identification of Phenolic acids*:** Quantitative determination and identification of various phenolic acids in leaves, stem and whole plant extracts of lambsquarter and field bindweed was done through GC-MS. Agilent Technology Hewlett Packard 7890 A Gas chromatograph, coupled with Agilent Technology 5975 C inert XL EI/CI MSD mass detector (Agilent, USA) at 70 eV was used. Separation of acids was done by HP-5MS column (35 m x 0.20 mm x 0.25 µm) and temperature programing of 100°C - 185°C with the step of 15°C/min and 185°C - 320°C with the step of 5°C/min, held on 320°C for 10 min was maintained. 250°C injector temperature and 1.0 mL/min carrier gas (helium) flow rate was used. Up to 1µL injection volume was adjusted. Retention time of the standards and different phenolic acids extracted from test samples were compared.

***Anti-oxidant enzymes bioassay*:** Leaves, stem and whole plant extracts of lambsquarter and field bindweed were assayed for antioxidant activities. Catalase, peroxidase and superoxide dismutase bioassays were performed by pre-described methods in literature (Kato and Shimizu, 1985; Beyer Jr and Fridovich, 1987). Briefly, Catalase (CAT) (EC 1.11.1.6) was evaluated by measuring H_2O_2 disappearance at 240nm absorbance, extinction coefficient (40 mM^{-1} cm^{-1} at 240 nm) was calculated and expressed in units of µM of destroyed H_2O_2 ($min^{-1}g^{-1}$ fresh wt). Peroxidase (EC 1.11.1.7) activity was measured as the change in optical density of pyrogallol (min^{-1} g^{-1}, fresh wt). Also, superoxide dismutase (SOD) (EC 1.15.1.1) activity was evaluated by measuring the amount of the enzyme required for photo reduction inhibition of NBT by 50% (U mg^{-1} FW).

***Statistical analysis*:** Data were analyzed by using Statistics 8.1 version software. Fisher's analysis was used to test the significance of means. Means were compared using the least significant difference test at 5% probability level (Steel *et al*., 1997). The computer based software Microsoft Excel 2010 was used to prepare the graphs.

RESULTS

***Petri dish bioassay*:** Results revealed (Fig 1-9) that all the treatments of lambsquarter and field bindweed leaf, stem and whole plant aqueous extracts have significantly affected the growth attributes of Camelina even in the most dilute concentration (2.50%). Minimum time to 50% germination and maximum germination percentage, germination energy, germination or emergence index, mean germination, seedling fresh & dry weight, seedling length and seed vigor index were recorded for control and treated plants. Statistically drastic changes in growth attributes of Camelina were credited to 10% whole plant aqueous extracts of lambsquarter and field bindweed. 10% whole plant aqueous extract of lambsquarters significantly affected the germination traits and produced minimum germination percentage (Fig 1), took maximum time to complete 50% germination (Fig 2), with minimum germination energy (Fig 3), that reduced the emergence index (Fig 4) and took maximum time to complete mean germination (Fig 5). Aqueous extract of both weeds adversely affected the seedling attributes. However, 10% whole plant aqueous extract of lambsquarters significantly reduced seedling traits and produced minimum seedling fresh (Fig 6) and dry weight (Fig 7), seedling length (Fig 8) and seed vigor index (Fig 9) as compared to other treatments.

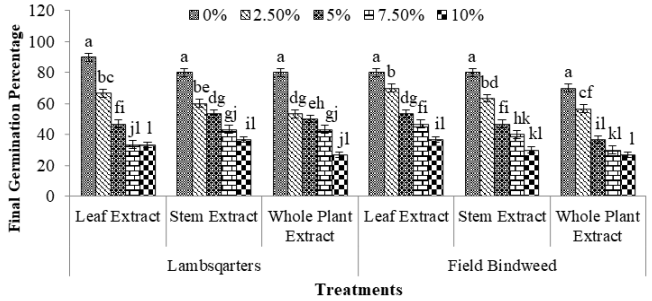


Figure 1. Allelopathic effect of aqueous extracts of different parts of lambsquarters and field bindweed on germination percentage of camelina seeds.

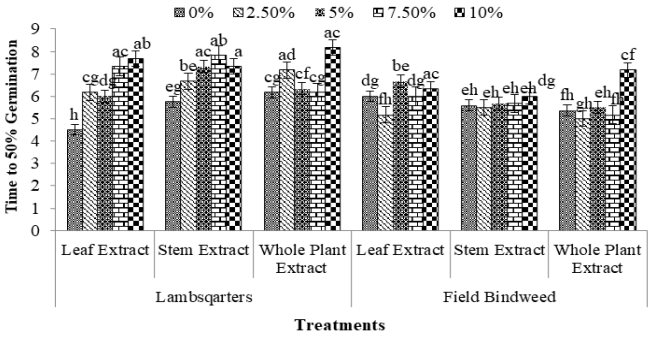


Figure 2. Allelopathic effect of aqueous extracts of different parts of lambsquarters and field bindweed extract on time to 50% germination/emergence of camelina seeds.

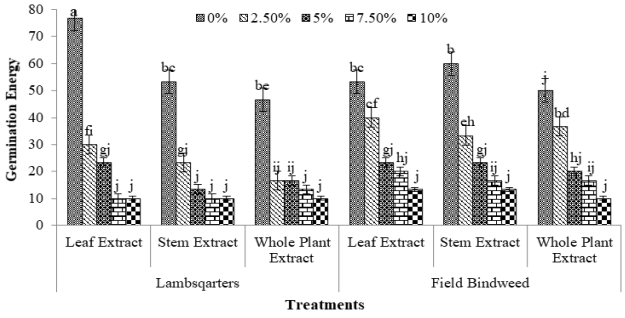


Figure 3. Allelopathic effect of aqueous extracts of different parts of lambsquarters and field bindweed extract on germination energy of camelina seeds.

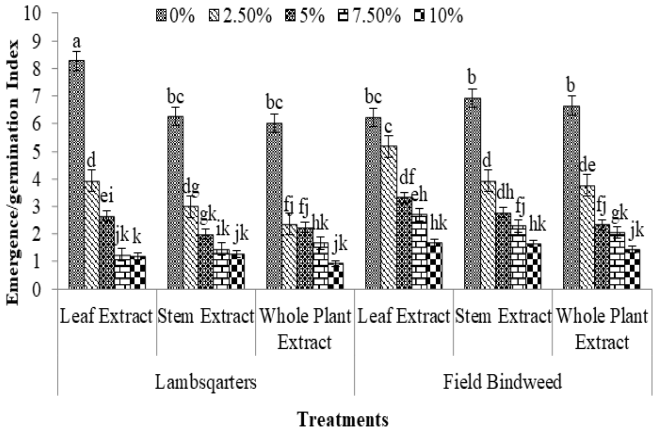


Figure4. Allelopathic effect of aqueous extracts of different parts of lambs quarters and field bindweed extract on emergence/germination index of camelina seeds.

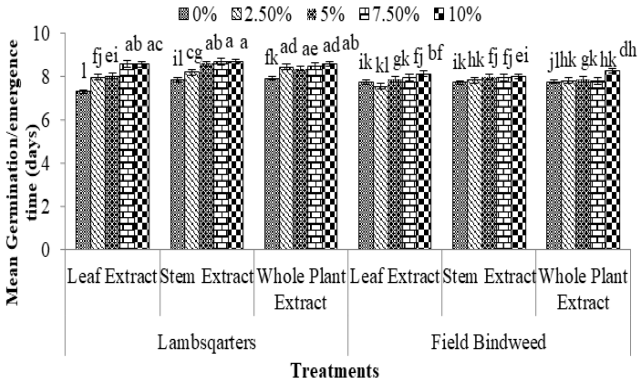


Figure 5. Allelopathic effect of aqueous extracts of different parts of lambsquarters and field bindweed extract on mean germination/emergence time (days) of camelina seeds.

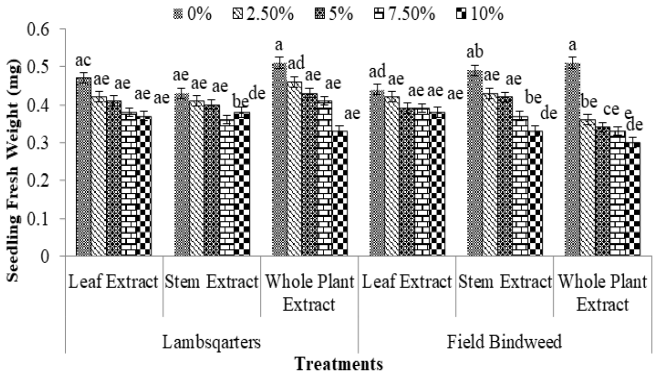


Figure 6. Allelopathic effect of aqueous extracts of different parts of lambsquarters and field bindweed extract on seedling fresh weight (mg) of camelina.

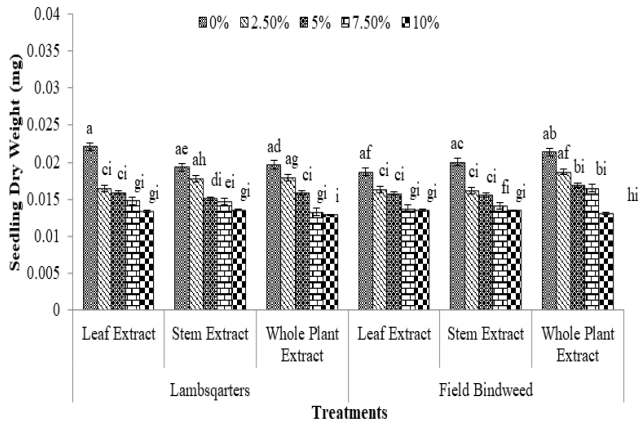


Figure 7. Allelopathic effect of aqueous extracts of different parts of lambsquarters and field bindweed extract on seedling dry weight (mg) of camelina seeds.

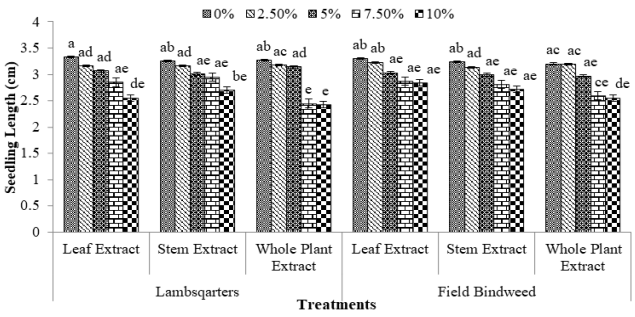


Figure 8. Allelopathic effect of aqueous extracts of different parts of lambsquarters and field bindweed extract on seedling length (cm) of camelina seeds.

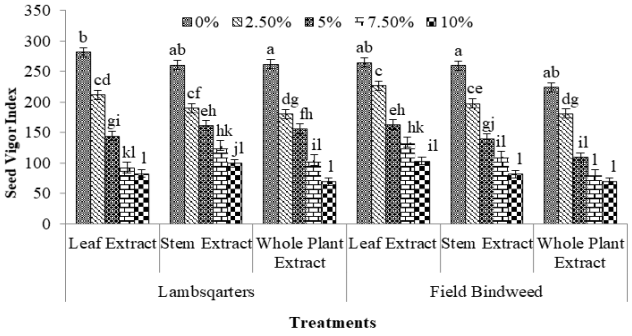


Figure 9. Allelopathic effect of aqueous extracts of different parts of lambsquarters and field bindweed extract on seed vigor index of camelina.

Pot experiment results: Chopped lambsquarter and field bindweed whole plants were incorporated in soil filled in pots. Camelina seeds were sowed in weed-incorporated soil after

specific time intervals i.e. 0, 15 and 30 days. Incorporation of chopped plants of both weeds significantly affected the leaf chlorophyll contents of camelina. Incorporation of field bindweed chopped plants at the time of sowing produced minimum leaf chlorophyll contents (Fig 10). While maximum leaf chlorophyll contents were observed from control plots. Leaf area index of camelina recorded at different growth stages was significantly affected by the incorporation of both weed plants. Incorporation of field bindweed chopped plants at the time of sowing produced minimum leaf area index at 40 days after sowing against the maximum was observed from control plots at 80 days after sowing (Fig. 11). Incorporation of chopped plants of both weeds significantly affected the plant height, yield and yield contributing attributes of camelina. Incorporation of field bindweed chopped plants at the time of sowing produced minimum plant height (Fig. 12), number of pods per plant (Fig. 13), number of seeds per pod (Fig 14) that ultimately reduced the biological yield (Fig 15) and seed yield (Fig 16). While maximum plant height, yield and yield contributing parameters were recorded from control plots.

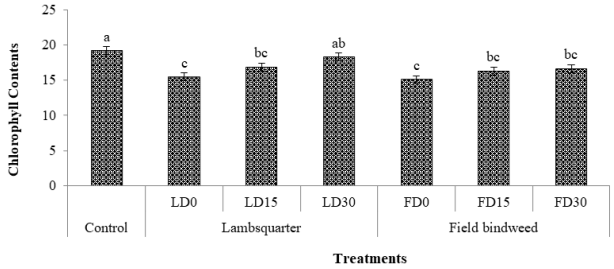


Figure 10. Effect of soil incorporated lambsquarter and field bindweed residues on cholorophyll contents of camelina.

Where LD_0, LD_{15} and LD_{30} is incorporation of lambsquarter chopped material at the time sowing, 15 days and 30 days before sowing, respectively. Similarly, FD_0, FD_{15} and FD_{30} is incorporation of field bindweed chopped material at the time sowing, respectively

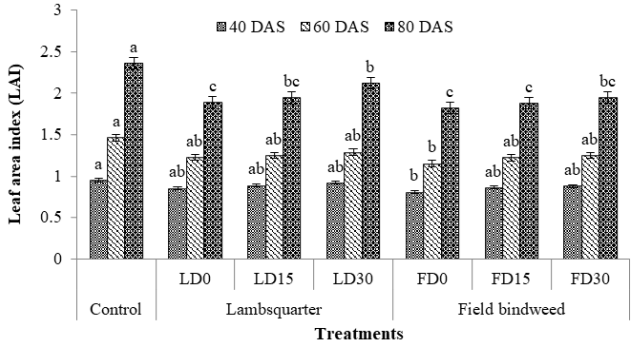


Figure11. Effect of soil incorporated lambsquarter and field bindweed residues on leaf area index of camelina.

Where LD_0, LD_{15} and LD_{30} is incorporation of lambsquarter chopped material at the time sowing, 15 days and 30 days before sowing, respectively. Similarly, FD_0, FD_{15} and FD_{30} is incorporation of field bindweed chopped material at the time sowing, respectively

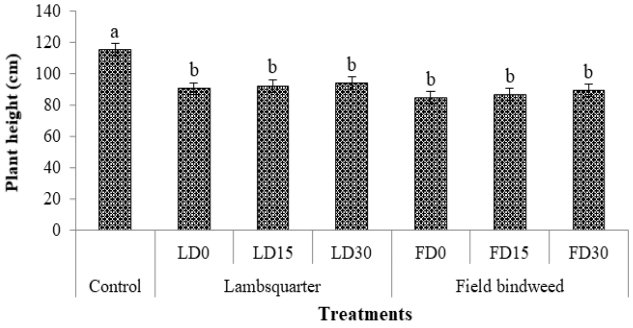


Figure12. Effect of soil incorporated lambsquarter and field bindweed residues on plant height (cm) of camelina.

Where LD_0, LD_{15} and LD_{30} is incorporation of lambsquarter chopped material at the time sowing, 15 days and 30 days before sowing, respectively. Similarly, FD_0, FD_{15} and FD_{30} is incorporation of field bindweed chopped material at the time sowing, respectively

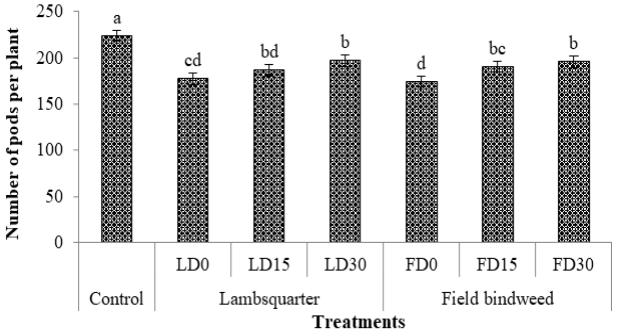


Figure 13. Effect of soil incorporated lambsquarter and field bindweed residues on number of pods per plant of camelina.

Where LD_0, LD_{15} and LD_{30} is incorporation of lambsquarter chopped material at the time sowing, 15 days and 30 days before sowing, respectively. Similarly, FD_0, FD_{15} and FD_{30} is incorporation of field bindweed chopped material at the time sowing, respectively

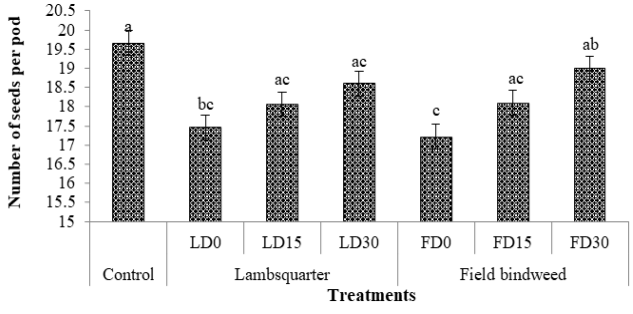


Figure 14. Effect of soil incorporated lambsquarter and field bindweed residues on number of seeds per pod of camelina.

Where LD_0, LD_{15} and LD_{30} is incorporation of lambsquarter chopped material at the time sowing, 15 days and 30 days before sowing, respectively. Similarly, FD_0, FD_{15} and FD_{30} is incorporation of field bindweed chopped material at the time sowing, respectively

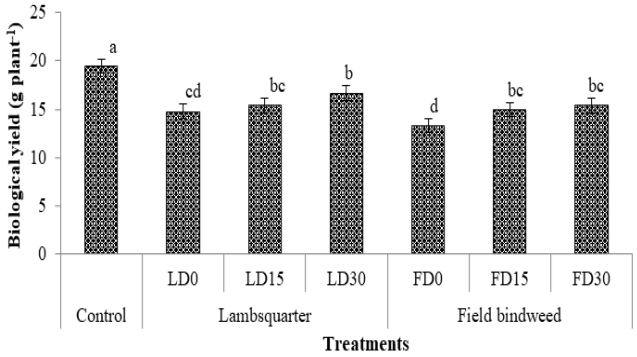


Figure 15. Effect of soil incorporated lambsquarter and field bindweed residues on biological yield (g plant^{-1}) of camelina.

Where LD_0, LD_{15} and LD_{30} is incorporation of lambsquarter chopped material at the time sowing, 15 days and 30 days before sowing, respectively. Similarly, FD_0, FD_{15} and FD_{30} is incorporation of field bindweed chopped material at the time sowing, respectively

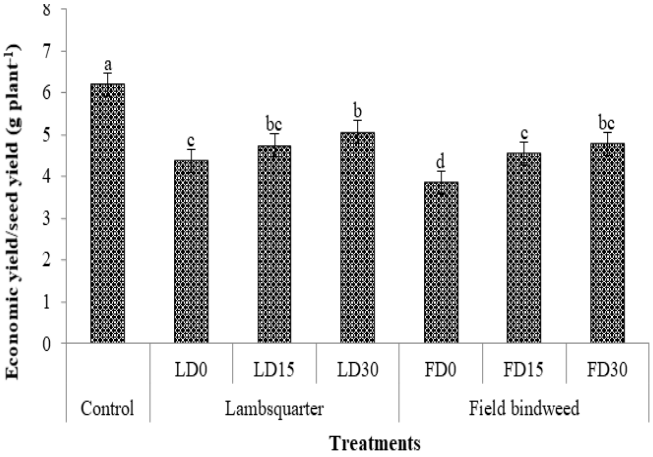


Figure 16. Effect of soil incorporated lambsquarter and field bindweed residues at different times on economic yield/seed yield (g plant^{-1}) of camelina.

Where LD_0, LD_{15} and LD_{30} is incorporation of lambsquarter chopped material at the time sowing, 15 days and 30 days before sowing, respectively. Similarly, FD_0, FD_{15} and FD_{30} is incorporation of field bindweed chopped material at the time sowing, respectively

***Phenolic acids in lambsquarter and field bindweed aqueous extracts*:** In order to explore the presence of phytotoxins/allelochemicals, GC-MS analysis was done, by applying whole plant, leaves and stem aqueous extracts of lambsquarter and field bindweed on camelina seeds. From the mass spectra and retention indices (R_t), various phenolic acids were identified and quantified. Gallic acid, vanillic acid, protocatechuic acid, chlorogenic acid, caffeic acid, *p*-coumaric acid, ferulic acid and *p*-hydroxybenzoic acid were identified. Figure 17 and 18 represents GC-MS chromatograms indicating the retention times of phenolics from aqueous extracts of both weeds. From each peak area, their concentrations were calculated. Results were also summarized in Table 1 in order of their retention times and concentration. The analyzed quantities of the weed phenolic acids were based on a comparison of retention times of standard phenolic acids with those in weed extracts.

Maximum amount of each acid in various plant parts of both weeds was in the order of whole plant > leaves > stem extracts. In lambsquarter, chlorogenic acid was found to be most abundant in all extracts in above order. While protocatechuic acid was calculated in lowest amount in all extracts. In field bindweed, *p*-coumaric acid was recorded as highest in all extracts and protocatechuic acid was least abundant.

***Antioxidant activity*:** Catalase (CAT), peroxidase (POD) and superoxide dismutase (SOD) bioassays were evaluated for leaves, stem and whole plant extracts of lambsquarter and field bindweed (Fig 19 and 20). It is clear from the results that all the treatments have inhibited antioxidant activity but the inhibitory effect was greater by the application of higher concentrations i.e. 10% whole plant extract of both weeds. Stem extract had shown least inhibition compared to control. This effect could be attributed to the presence of greater amount of phenolic acids in leaves and whole plant extracts, confirmed by GC-MS data (Table 1). Although, maximum inhibition was recorded for all three enzymes by 10% whole plant extracts of both weeds, but this effect is prominent for CAT (2.5%). While a negligible inhibition for CAT and SOD was shown by 2.5% stem extract of both weeds, comparable to control.

Table 1. GC-MS analysis report of effect of aqueous extracts of whole plant, leaves and stem of lambsquarter and field bindweed on camelina

	Retention Time (R_t) (min)		Phenolic Acids Concentration (%) by Applying Aqueous Weed Extracts					
			Whole Plant		Leaves		Stem	
Phenolic Acids	***C. Album***	***C. arvensis***	***C. Album***	***C. arvensis***	***C. Album***	***C. arvensis***	***C. Album***	***C. arvensis***
Gallic Acid	0.5	0.84	24.51	27.22	20.56	23.31	22.37	20.11
Vanillic Acid	0.8	2.92	13.12	24.45	10.72	20.31	7.86	18.42
Protocatechuic Acid	1.7	4.23	5.31	10.51	4.63	8.44	3.31	7.82
Chlorogenic Acid	2.6	3.81	42.23	15.34	38.42	14.83	23.45	14.12
Caffeic Acid	4.2	3.24	13.41	13.84	7.33	12.84	9.36	11.32
p-coumaric Acid	5.5	1.88	19.09	45.21	17.21	38.24	15.62	28.67
Ferulic Acid	6.6	2.61	6.46	38.41	4.57	32.71	5.24	28.55
p-hydroxybenzoic aAcid	9.6	4.82	9.41	39.31	7.51	34.71	6.12	30.65

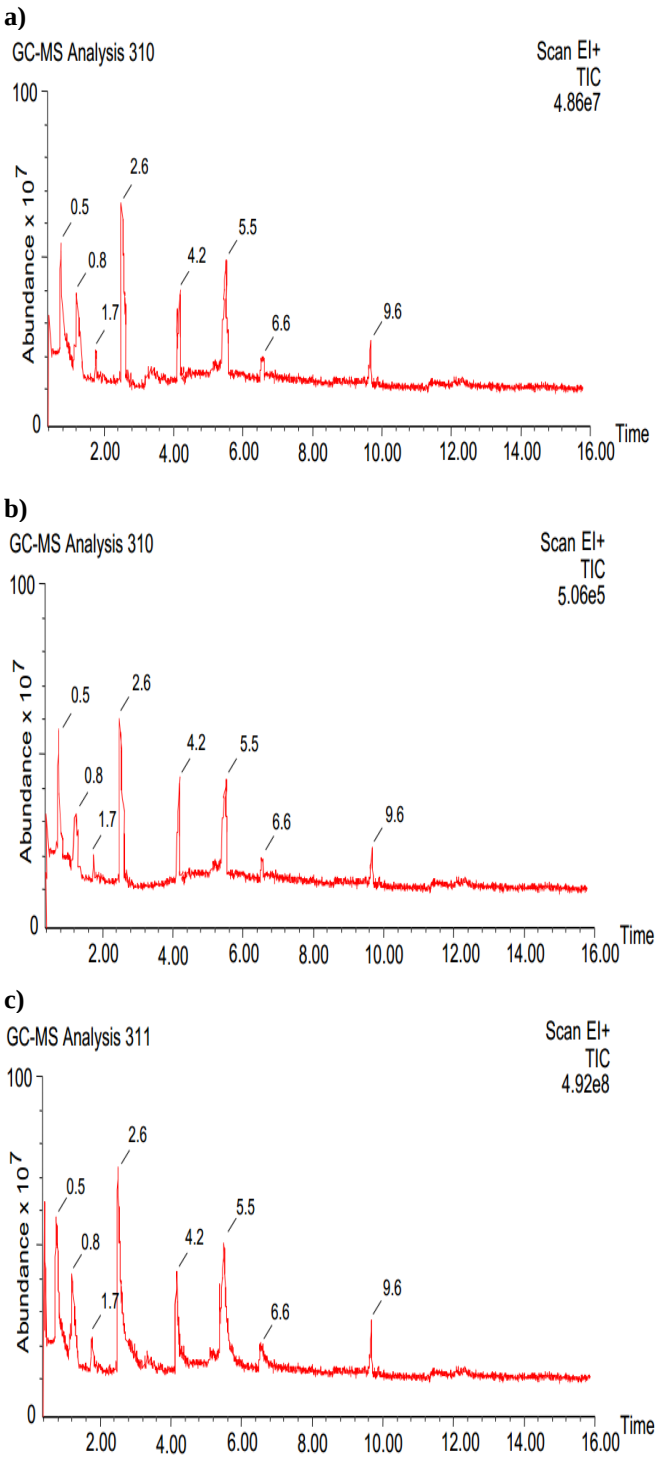


Figure 17. GC-MS Chromatograms of lambsquarter (*Chenopodium album*) a)leaves b)stem c)whole plant extracts

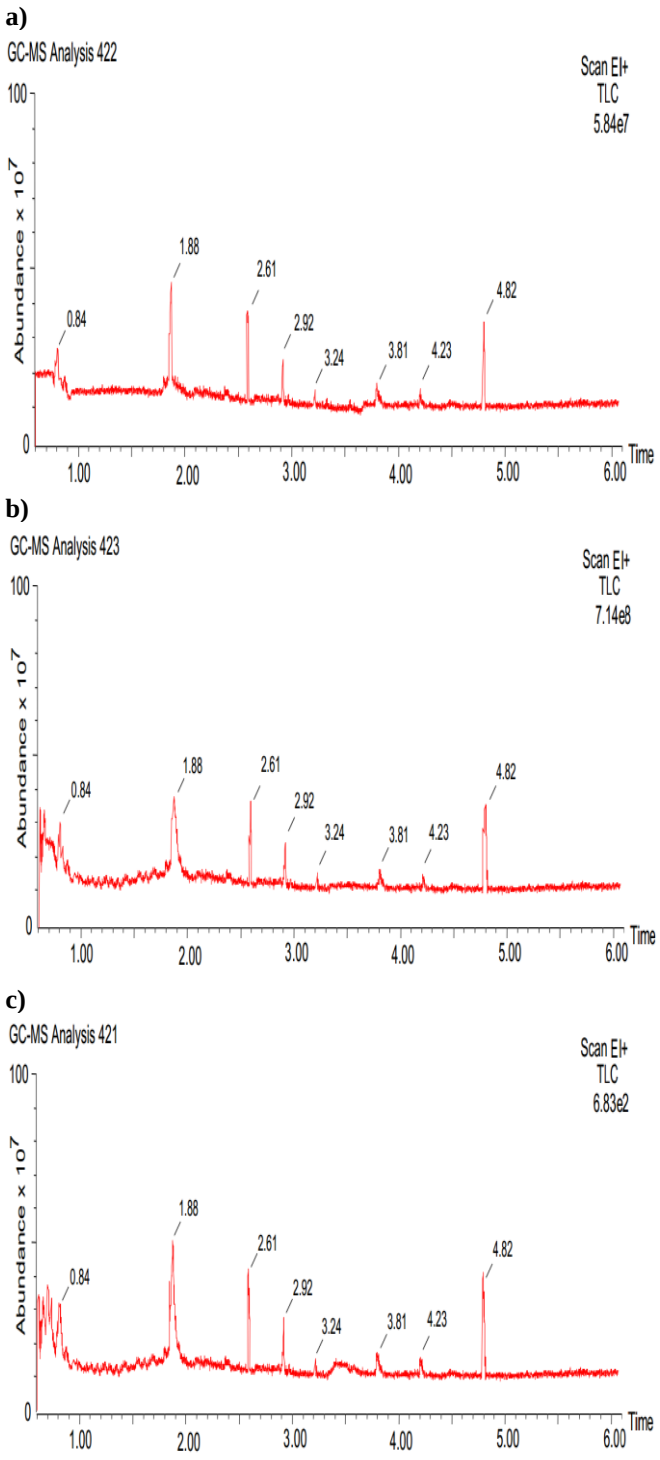
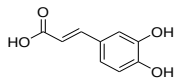
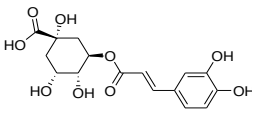
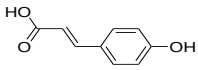
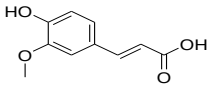
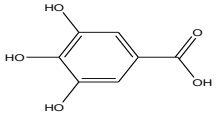
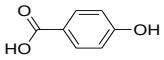
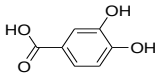
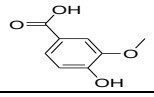


Figure.18. GC-MS Chromatograms of field bindweed (*Convolvulus arvensis*) a)leaves b)stem c)whole plant extracts

Table 2. Complete description of accurate mass analysis of phenolic acids found in lambsquarter and field bindweed extracts by MS spectra.

Phenolic Acids	Mol. Formula	Mol.Wt (g/mol)	Structural Formula
Caffeic Acid	$C_9H_8O_4$	180.16	
Chlorogenic Acid	$C_{16}H_{18}O_9$	354.31	
p-Coumaric Acid	$C_9H_8O_3$	164.05	
Ferulic Acid	$C_{10}H_{10}O_4$	194.18	
Gallic Acid	$C_7H_6O_5$	170.12	
p-Hydroxybenzoic Acid	$C_7H_6O_3$	138.12	
Protocatechuic Acid	$C_7H_6O_4$	154.12	
Vanillic Acid	$C_8H_8O_4$	168.15	

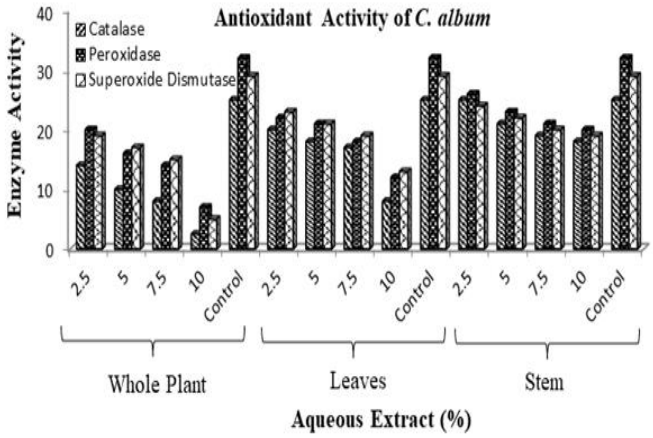


Figure 19. Effect of various aqueous extract treatments (%) of whole plant, leaves and stem of lambsquarter (*C. album*) on catalase activity (H_2O_2 destroyed, µM, $min^{-1}g^{-1}$ fresh wt), peroxidase activity (OD pyrogallol µM, $min^{-1}g^{-1}$ fresh wt), superoxide dismutase (NBT, U mg^{-1} fresh wt).

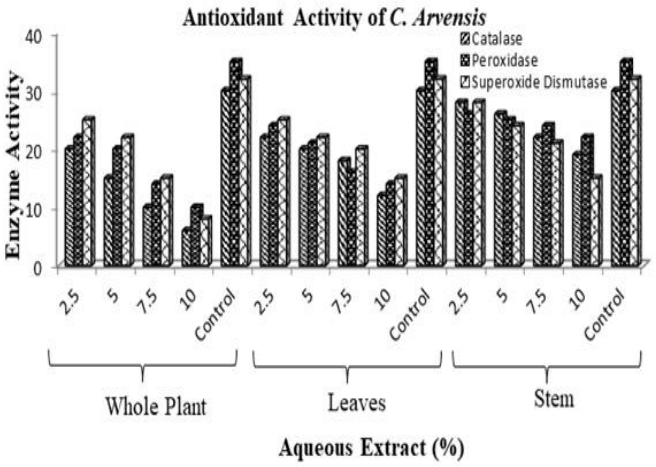


Figure 20. Effect of various aqueous extract treatments (%) of whole plant, leaves and stem of field bindweed (*C. arvensis*) on catalase activity (H_2O_2 destroyed, µM, $min^{-1}g^{-1}$ fresh wt), peroxidase activity (OD pyrogallol µM, $min^{-1}g^{-1}$ fresh wt), superoxide dismutase (NBT, U mg^{-1} fresh wt).

DISCUSSION

Weeds are regarded as much dangerous, unwanted and disruptive constituent of the world's flora due to their vast overwhelming capacity. As weeds have high competitive potential of acclimatization to the environment, not only there is competition between the crop and various weeds for nutrients, water, air, light and space but this competition also releases different types of allelochemicals which affect the germination and crop yield (Kakar *et al*., 2016). These allelochemicals can affect the normal functioning of the plant life including photosynthesis, respiration, mineral nutrition, transpiration, resistance and growth (Surendraraj *et al*., 2013). These compounds are the natural phenolic acids, which within a specific concentration range have stimulatory effects on plant growth, seed germination, antioxidant activity and chlorophyll contents. But at high concentrations, these can inhibit germination and antioxidant activities, also reduce carbohydrates and protein contents. So, inhibitory action of weed extracts is the function of the concentration (Hegab and Ghareib, 2010).

The results of the present study revealed a significant inhibitory effect of higher concentration of the aqueous treatments of lambsquarter and field bindweed leaf, stem and whole plant on germination and seedling attributes of Camelina (Fig 1-9), particularly whole plant extracts. Alteration in cell division or mitotic action, hindrance in protein arrangements and abnormalities in gibberellins action etc. could be the primary reasons of germination and seedling development retardation (Hegab and Ghareib, 2010).

As far as, the effect of whole plant residues of both weeds is

concerned, results revealed that, with the passage of time, weeds residue effect decreased on Camelina (Fig 10-16). This may be due to the fact that by the time plant decomposition increases in soil, various phenolics interact with microbes or with soil nutrients that leads to the non-availability of phtyotoxins to the desired crop (Surendraraj *et al*., 2013). Previous literature had also described that reduction in crop growth attributes is dependent on weed or its debris, regardless it is leaf, stem or entire plant (El-Rokiek *et al*., 2016). According to Khan *et al*. (2012) weeds continuously pour various allelochemicals into the soil, for example alkaloids, carotenoids, flavonoids, phenolics or steroids. The amount of different phenolic acids varies in different plant tissues i.e. usually, leaves have much greater amount than ariel parts or roots, as leaves are the synthetic sites of almost all the biomolecules (Dores *et al*., 2014). Results of the present study have confirmed an unequal distribution of eight water soluble phenolic acids namely gallic acid, vanillic acid, protocatechuic acid, chlorogenic acid, caffeic acid, *p*-coumaric acid, ferulic acid and *p*-hydroxybenzoic acid in aqueous extracts of different parts of lambsquarter and field bindweed (Table 1). Previous researches had also confirmed that, these phenolic acids could interfere with plant physiological processes. Like chlorogenic acid (an ester of caffeic acid and quinic acid), a natural plant growth inhibitor, can reduce the growth of nitrifying and nitrogen fixing bacteria. Also it can strongly inhibit indole acetic acid oxidase activity. Stomatal closure in *Nicotiana tabacum* L. and *Helianthus annuus* L. seedlings and growth reduction in *Solanum lycopersicum* L. tomato plants and Cyanobacteria blue green algae were studied and credited to the presence of chlorogenic, caffeic and *p*-coumaric acid (Yan *et al*., 2015). Few studies have described cooperative inhibitory effects of vanillic & *p*-hydroxybenzoic acid and ferulic & *p*-coumaric acid, even in very small amount. Combination of these acids in weed or soil can impart a potential hazard to desired crop growth (Surendraraj *et al*., 2013). Dores *et al*. (2014) also reported that vanillic acid could directly influence mitochondrial respiration and inhibit Ca^{2+} uptake. It was observed that *p*-coumaric acid (hydroxy derivative of cinnamic acid), can alter cell membrane permeability and hence affect the normal functioning of cell (Lou *et al*., 2012). In the present study, results have shown that by increasing concentration of various aqueous extract treatments of lambsquarter and field bindweed to camelina, antioxidant activities of CAT, POD and SOD enzymes were significantly reduced. This reduction was possibly due to the excessive accumulation of phenolic acids (allelochemicals), analyzed by GC-MS. Yan *et al*. (2015) had also described that the impact of allelochemicals on plant antioxidant enzyme system is concentration dependent. Our results are consistent to previous studies i.e. a decline in NADPH oxidase, SOD, POD, CAT activities due to increased amounts of allelochemicals in cucumber, sorghum, rape seeds, corn and lettuce were investigated by Talukder (2020).

To alleviate the detrimental effects of overproduction of ROS (Reactive Oxygen Species i.e. $^{\bullet}OH$, H_2O_2, $O_2^{\bullet-}$, $^1O_2$etc), the plants have a complex enzymatic and non-enzymatic antioxidant system i.e. superoxide dismutase, peroxidase, catalase, α-tocopherol, ß-carotene, polyamines & ascorbic acid. The ROS (oxidative damage) increases due to excessive accumulation of allelochemicals, it greatly hampers the activity of antioxidant enzymes. Few other researchers had also investigated an increase in oxidative damage by allelochemicals in plants (Chi *et al*., 2011).

Conclusion: This investigation revealed that *Chenopodium album* and *Convolvulus arvensis* are rich source of phenolic acids that greatly inhibited antioxidant activity which ultimately adversely affect the germination; seedling development and seed yield of camelina.

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