Influence of Residual Allelopathic Effects of the Seed Powder of Watercress or Mustard on the Following Cowpea Plant and Its Associated Weeds

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ABSTRACT

Cowpea (Vigna unguiculata (L.) Walp.) plants were sown in the same pots after the harvest of tomato plants which were previously treated with different rates (5, 10, 15, 30 and 45g/kg soil) of seed powder of two Brassicaceae plants, watercress (Eruca Sativa M.) or mustard (Sinapis alba L.) compared to those treated with Basamid herbicide at 0.2 g/pot. This work was done in the greenhouse of the Egyptian National Research Centre during the two successive summer seasons of 2017 and 2018. The obtained results indicated that all previous treatments used to tomato were significantly minimized the weight (fresh and dry) of grasses, broad-leaved and the total weeds associated with the following cowpea plants, at 45 and 85 days after sowing (DAS). Generally, all treatments with watercress were more effective than mustard in controlling both broad leaved weeds and grasses. Moreover, broad leaved weeds were more susceptible than grasses. The results also showed that all mentioned treatments had significant effect on cowpea plants, significantly increasing most growth parameters and yield and yield components. The results indicated that all tested treatments had no toxic effects on the following cowpea plants.

Keywords: Basamid herbicide, cowpea, mustard, residual effect, tomato, watercress.

1. Introduction

Cowpea (Vigna unguiculata (L.) Walp.) is a multifunctional food crop for humans and animals. Cowpeas are vital to the livelihood of the poor people in tropical least developed countries. Its seeds are composed of 53% carbohydrates, 24% crude protein and 2% fat (FAO, 2012). In addition to its importance as human food, cowpea is also useful for soil fertilization through symbiotic nitrogen fixation and can be a major animal feed due to the nutritive quality of its leaves (Diouf, 2011). Since ancient times, weeds are recognized as plant pests (Zimdahl, 2013) as it cause serious damage and considerable loss in the productivity of crops through a continuous competition with crops for the solar radiation, space, soil nutrients and water. Harnessing the allelopathic phenomenon is one of the important innovative weed control methods used to suppress weeds (Jabran and Farooq, 2013 and Zeng, 2014). Fighting the implications of weeds in crop production is the main aim of the practical allelopathic applications for weed control in agricultural systems. Jabran et al. (2015) discussed using allelopathic cover crops and residues as well as their rotational sowing for practical weed control in field crops. A strong allelopathic potential has been demonstrated for the Brassicaceae family against other crops and weed plants (Haramoto and Gallandt, 2004; El-Dabaa et al., 2019; El-Masry et al., 2019). Brassicas produce glucosinolates as allelochemical compounds, through their plant parts with different concentrations (Fahey et al., 2001). Several biologically active compounds (allelochemicals) such as isothiocyanates, nitriles, thiocyanates, epithionitriles and oxazoqionines are produced from the decomposition of glucosinolates which have been released into the environment through volatilization (Morra and Kirkegaard, 2002 and Bones and Rossiter, 2006). These allelochemicals, mainly
isothiocyanates, suppress the growth and development of weeds which take them up (Petersen et al., 2001; Messiha et al., 2013, 2018; El-Masry et al., 2015; Ahmed et al., 2020 a). Brassica plants can be used as cover crops, intercropping brassica crops with the main crop, crop rotation or the use of brassica litter as mulch to suppress weeds through its allelopathic potential (Haramoto and Gallandt, 2005; Rice et al., 2007; Bangarwa and Norsworthy, 2014; Ahmed et al., 2020 b). Recent researches indicate that allelopathic plants have enormous effect to suppress weeds and at the same time it can improve the growth, yield and yield components of the crops (Ahmed et al., 2018; El-Rokiek et al., 2018; Messiha et al., 2018; El-Wakeel et al., 2019, 2020; El-Wakeel and El-Metwally, 2020).

So, the main objective of this work is to study the residual allelopathic effect of the seed powder of watercress or mustard, as two plants from the Brassicaceae family, on the growth of the following summer cowpea crop and its associated weeds.

2. Materials and Methods

The greenhouse of the Egyptian National Research Centre, Dokki, Giza was used to conduct two pot experiments during the two summer seasons of 2017 and 2018 to study the residual allelopathic effects of different rates of the seed powders of two plants from the Brassicaceae family; watercress (*Eruca sativa*) or mustard (*Sinapis alba*), as well as Basamid herbicide (Dazomet) on the cowpea (*V.unguiculata*) plants. A randomized complete design with six replicates was used. Each experiment includes the previously used pots which were applied to tomato (*Lycopersicon esculentum*) as follows:

| Treatment | Description |
|-----------|-------------|
| T1        | Tomato+ Broomrape (Infected control). |
| T2        | Tomato + Broomrape + Watercress at 5g/kg soil |
| T3        | Tomato + Broomrape + Watercress at 10g/kg soil |
| T4        | Tomato + Broomrape + Watercress at 15g/kg soil |
| T5        | Tomato + Broomrape + Watercress at 30g/kg soil |
| T6        | Tomato + Broomrape + Watercress at 45g/kg soil |
| T7        | Tomato+ Broomrape + Mustard at 5g/kg soil |
| T8        | Tomato + Broomrape + Mustard at 10g/kg soil |
| T9        | Tomato + Broomrape + Mustard at 15g/kg soil |
| T10       | Tomato + Broomrape + Mustard at 30g/kg soil |
| T11       | Tomato + Broomrape + Mustard at 45g/kg soil |
| T12       | Tomato + Broomrape + Basamid 0.2 g/pot |

After tomato harvest, each pot was cleaned without disturbing the soil surface, therefore the emerging weeds were considered as the still viable and non-affected summer weeds from the previous treatments. Seeds of cowpea “Dokki331” cultivar were sown on 9th and 8th May of 2017 and 2018 seasons, respectively. Fertilization and irrigation were performed as in the normal agricultural practices of growing plants.

2.1. Data recorded:

A. On weeds:

At 45 and 85 days after sowing (DAS), weeds were hand removed from two pots of every treatment. The fresh and dry weight of the removed weeds (broad-leaved, grasses and total weeds (g/pot)) was recorded.

B. On cowpea plants:

1- Plant growth

After 45 and 85 DAS, six cowpea plants from each treatment were collected and the following growth characteristics; plant height (cm), leaves number /plant, branches number /plant (at 85 DAS only), fresh and dry weight of plant (g) were recorded for each individual plant.

2- Yield and yield components

At harvest, pods number / pot, pods fresh and dry weight /pot, pod length (cm), seeds number /pod, seeds weight / 10 pods (g) and weight of 100 seeds (g) were determined for cowpea samples.
2.2. Chemical measurements

A) Determination of total glucosinolates (µ mol/g DW)

Total glucosinolates were extracted from dry seed powder of watercress or mustard. According to Rauchberger et al., (1979), glucosinolates were determined by colorimetric measurement of the glucose released during hydrolysis by myrosinase enzyme (Nasirullah and Krishnamurthy, 1996).

B) Determination of total phenolic content (mg/g DW)

A colorimetrical determination of total phenolic content in the seed powder of watercress or mustard was carried out according to Snell and Snell (1953).

2.3. Statistical Analysis

A statistical analysis was performed on all results according to the Snedecor and Cochrans (1980) where LSD at 5% probability level was used to compare treatment means.

3. Results and Discussion

3.1. Residual effect from the previous tomato treatments on the associated summer weeds grown with cowpea plants

It is evident from the data in Tables 1 and 2 that all of the previous tomato treatments significantly reduced both fresh and dry weights of broad-leaved, grasses and the total weeds associated with the following cowpea crop at 45 and 85 days after sowing (DAS) as compared to infected control (Tomato + Broomrape). In the two growth ages, 45 and 85 DAS, the broad-leaved weeds disappeared with treatments of 30 and 45g/kg soil of watercress, 45g/kg soil of mustard and the 0.2g/pot of Basamid treatments. The reduction rate of fresh and dry weight of grasses and total weeds was found to increase by increasing the rate used for both watercress and mustard. The highest reduction in the dry weight of grasses and total weeds were recorded as follow: 45g/kg soil of watercress, 0.2g/pot were of Basamid herbicide, 30g/kg soil watercress as well as 45g/kg soil mustard treatments. These treatments reduced the dry weight of the total weeds at 85 DAS to 86.59, 75.45, 69.18 and 66.03%, respectively when compared to infected control.

Table1: The allelopathic influence of the seed powder of watercress and mustard as well as Basamid rates previously applied to the winter tomato plants on the fresh and dry weight of weeds grown with cowpea plants at 45 days after sowing (g/pot) (Average results of 2017 and 2018 experiments).

| Previous treatments | Fresh weight of weeds (gm) | Dry weight of weeds (gm) |
|---------------------|----------------------------|--------------------------|
|                     | Broad-leaved | Grasses | Total | Broad-leaved | Grasses | Total |
| T1                  | 40.90        | 115.0   | 155.90 | 12.58        | 23.65   | 36.23 |
| T2                  | 16.55        | 89.0    | 105.55 | 3.28         | 18.33   | 21.61 |
| T3                  | 13.30        | 79.1    | 92.40  | 2.63         | 16.31   | 18.94 |
| T4                  | 4.00         | 55.1    | 59.10  | 1.00         | 11.20   | 12.20 |
| T5                  | 0.00         | 45.5    | 45.50  | 0.00         | 9.68    | 9.68  |
| T6                  | 0.00         | 32.9    | 32.90  | 0.00         | 9.01    | 9.01  |
| T7                  | 22.80        | 100.5   | 123.30 | 4.52         | 20.68   | 25.20 |
| T8                  | 16.75        | 94.2    | 110.95 | 3.32         | 19.40   | 22.72 |
| T9                  | 13.15        | 73.5    | 86.65  | 2.60         | 15.15   | 17.75 |
| T10                 | 1.70         | 68.6    | 70.30  | 0.62         | 14.15   | 14.77 |
| T11                 | 0.00         | 50.8    | 50.80  | 0.00         | 10.50   | 10.50 |
| T12                 | 0.00         | 43.5    | 43.50  | 0.00         | 9.42    | 9.42  |

L.S.D.0.05 1.58 3.0 2.01 0.72 1.55 1.84

T1 Tomato + Broomrape (Infected control).
T2 Tomato + Broomrape + Watercress at 5g/kg soil
T3 Tomato + Broomrape + Watercress at 10g/kg soil
T4 Tomato + Broomrape + Watercress at 15g/kg soil
T5 Tomato + Broomrape + Watercress at 30g/kg soil
T6 Tomato + Broomrape + Watercress at 45g/kg soil
T7 Tomato + Broomrape + Mustard at 5g/kg soil
T8 Tomato + Broomrape + Mustard at 10g/kg soil
T9 Tomato + Broomrape + Mustard at 15g/kg soil
T10 Tomato + Broomrape + Mustard at 30g/kg soil
T11 Tomato + Broomrape + Mustard at 45g/kg soil
T12 Tomato + Broomrape + Basamid 0.2 g/pot
These increases reach to 159.85, 137.81, 124.26 and 123.03, respectively for soil watercress, 0.2g/pot Basamid herbicide, 30g/kg soil watercress and 45g/kg soil mustard treatments. The highest values of cowpea dry weight were recorded respectively at 85 DAS with these treatments as follow: 45g/kg soil watercress + Broomrape at 30g/kg soil mustard rates previously applied to the winter tomato plants on the fresh and dry weight of weeds grown with cowpea plants at 85 days after sowing (g/pot) (Average results of 2017 and 2018 experiments).

| Previous treatments | Cowpea height (cm) | Leaves number/plant | Cowpea fresh weight (g) | Cowpea dry weight (g) |
|---------------------|--------------------|---------------------|-------------------------|----------------------|
| T1                  | 77.0               | 11.3                | 31.18                   | 5.00                 |
| T2                  | 75.9               | 13.4                | 39.95                   | 6.52                 |
| T3                  | 64.1               | 13.8                | 40.17                   | 6.60                 |
| T4                  | 69.7               | 14.5                | 49.10                   | 7.35                 |
| T5                  | 75.9               | 15.8                | 55.10                   | 9.00                 |
| T6                  | 79.3               | 16.5                | 58.60                   | 9.60                 |
| T7                  | 52.0               | 12.5                | 35.00                   | 5.22                 |
| T8                  | 53.5               | 13.0                | 37.58                   | 5.80                 |
| T9                  | 64.3               | 13.8                | 41.85                   | 6.70                 |
| T10                 | 68.3               | 14.0                | 45.70                   | 7.11                 |
| T11                 | 75.3               | 15.3                | 54.80                   | 8.69                 |
| T12                 | 77.0               | 16.0                | 57.90                   | 9.10                 |

L.S.D_{0.05} 2.7 1.3 2.26 1.24

3.2. Residual effect from the previous tomato treatments on the growth of cowpea

Results presented in Tables 3 and 4 indicate that all previous treatments of tomato pots were significantly increased all cowpea growth parameters in the two ages of growth (45 and 85 DAS) except for watercress treatment at 5g/kg soil on the number of branches/plant at 85 DAS as well as mustard treatments at 5 and 10g/kg soil on some growth characters at 45 and 85 DAS. All growth characters were found to increase by increasing the rate used of both watercress and mustard. The highest values of cowpea dry weight were recorded respectively at 85 DAS with these treatments as follow: 45g/kg soil watercress, 0.2g/pot Basamid herbicide, 30g/kg soil watercress and 45g/kg soil mustard treatments. These increases reach to 159.85, 137.81, 124.26 and 123.03, respectively over the infected control.
Table 4: The allelopathic influence of the seed powder of watercress and mustard as well as Basamid rates previously applied to the winter tomato plants on the following cowpea plant growth at 85 days after sowing. (Average results of 2017 and 2018 experiments).

| Previous treatments | Plant height (cm) | Leaves number/plant | Branches number/plant | Plant fresh weight (g) | Plant dry weight (g) |
|---------------------|-------------------|---------------------|-----------------------|------------------------|---------------------|
| T1                  | 112.0             | 14.0                | 1.0                   | 46.8                   | 8.12                |
| T2                  | 119.5             | 19.0                | 1.5                   | 62.1                   | 10.09               |
| T3                  | 125.0             | 19.5                | 1.7                   | 71.7                   | 10.75               |
| T4                  | 132.5             | 21.0                | 2.3                   | 83.0                   | 13.78               |
| T5                  | 152.9             | 24.0                | 3.0                   | 105.0                  | 18.21               |
| T6                  | 160.0             | 27.0                | 3.5                   | 110.5                  | 21.10               |
| T7                  | 116.5             | 16.9                | 1.1                   | 56.5                   | 9.32                |
| T8                  | 117.0             | 17.0                | 1.3                   | 60.0                   | 9.55                |
| T9                  | 126.5             | 20.0                | 2.0                   | 73.0                   | 11.70               |
| T10                 | 129.5             | 20.9                | 2.1                   | 80.5                   | 12.79               |
| T11                 | 152.0             | 23.8                | 2.8                   | 96.0                   | 18.11               |
| T12                 | 156.5             | 25.0                | 3.2                   | 107.0                  | 19.31               |
| L.S.D.0.05           | 3.7               | 2.3                 | 0.6                   | 2.9                    | 1.50                |

3.3. Residual effect from the previous tomato treatments on the yield and yield components of cowpea

The yield of cowpea and its components; i.e. pods number / pot, pods fresh and dry weight / pot, length of pod (cm), seeds number / pod, seeds weight / 10 pods (g) and weight of 100 seeds (g) are presented in Table-5. Results demonstrated that all of the previous treatments to tomato pots of watercress and mustard as well as 0.2g/pot Basamid herbicide had significant effect on all cowpea yield and its components except the lowest rate (5 g/kg soil) from the watercress seed powder on the weight of 100 seeds (g) and also mustard treatments at 5 and 10 g/kg soil on some yield components characters. The increase in the cowpea yield and its components was rate dependent of both watercress and mustard seed powder used. The highest values of the seeds weight /10 pods (g) and the weight of 100 seeds (g) were recorded respectively with those of the previous tomato treatments as follow: 45g/kg soil watercress, 0.2g/pot Basamid herbicide, 30g/kg soil watercress and 45g/kg soil mustard comparing with infected control. These increases reached to 106.25, 93.75, 81.25 and 68.75%, for the seeds weight /10 pods (g), while the weight of 100 seeds (g) reached to 42.11, 36.84, 36.84 and 31.58 % respectively more than the infected control. It is clearly noticed that the infected control recorded the lowest values of growth at both ages (45 and 85 DAS) as well as the cowpea yield and its components.

3.4. The content of total glucosinolates and total phenolics in the seed powder of watercress and mustard.

Total glucosinolates and total phenolics contents determined in the extracts of both watercress and mustard seed powder are represented in Table-6.

In Egypt, tomato cultivation could be followed by a summer crop such as cowpea in order to increase the Egyptian crop area per year. Therefore, it was thought advisable to study the residual effect of the seed powder of watercress or mustard plants of the Brassicaceae family, and Basamid herbicide as previous tomato treatment on the following summer cowpea plants.

Generally, the previously used treatments with either the seed powder of the two Brassicaceae plants or Basamid herbicide decreased the fresh and dry weight of broad-leaved weeds as well as grasses which are associated with the growth of the following cowpea plants. In this connection it should be mentioned that the present investigation and our previous report (Ahmed et al., 2020 b) are well
supported by the previous findings of Wolf et al., 1984, Teasdale and Taylorson, 1986, Bialy et al., 1990 Choesin and Boerner, 1990 and Petersen et al., 2001 which showed that the degradation products from the previously added seed powder from the two mentioned Brassicaceae plants contain Glucosinolates hydrolysis products which could inhibit the germination of many different seeds. The results of the present investigation indicate that most of the previously mentioned treatments had significant effect on the growth of cowpea plants and increased yield as well as its components. These results confirm the previous work which showed that the seed powder of the two mentioned Brassicaceae plants had a stimulatory effect on the preceding crop plant (Vilhorde et al., 1985; Angus et al., 1991; Oliva et al., 2002; Ahmed et al., 2018; El-Dabaa et al., 2019; El-Masry et al., 2019 and El-Wakeel et al., 2019). Similar reports showed that other Brassicaceae plants when incorporated into the soil as a green manure decreased the growth of emerging weeds in the following crop (Boydston and Hang, 1995; Al-Khatib et al., 1997 and Krishnan et al., 1998).

Table 5: Allelopathic influence of the seed powder of watercress and mustard as well as Basamid rates previously applied to the winter tomato plants on the following cowpea yield and yield components at harvest. (Average results of 2017 and 2018 experiments).

| Previous treatments | Pods number /pot | Pods F.W. /pot (g) | Pods D.W. /pot (g) | Pod length (cm) | Seeds No. /pod | Seeds weight /10pods(g) | Wt. of 100 seeds (g) |
|---------------------|------------------|--------------------|--------------------|-----------------|-----------------|------------------------|---------------------|
| T1                  | 16               | 33                 | 27                 | 15.6            | 6.8             | 16                     | 19                  |
| T2                  | 21               | 44                 | 36                 | 17.2            | 8.7             | 20                     | 21                  |
| T3                  | 23               | 47                 | 39                 | 17.6            | 9.4             | 21                     | 22                  |
| T4                  | 33               | 84                 | 73                 | 19.4            | 11.1            | 25                     | 24                  |
| T5                  | 43               | 120                | 100                | 20.3            | 12.0            | 29                     | 26                  |
| T6                  | 56               | 136                | 113                | 21.2            | 12.5            | 33                     | 27                  |
| T7                  | 18               | 39                 | 32                 | 16.4            | 8.0             | 18                     | 20                  |
| T8                  | 20               | 42                 | 35                 | 16.8            | 8.3             | 19                     | 21                  |
| T9                  | 25               | 57                 | 47                 | 18.3            | 9.9             | 23                     | 23                  |
| T10                 | 27               | 64                 | 53                 | 18.7            | 10.4            | 24                     | 23                  |
| T11                 | 41               | 99                 | 86                 | 20.0            | 11.5            | 27                     | 25                  |
| T12                 | 48               | 130                | 108                | 20.9            | 12.2            | 31                     | 26                  |

L.S.D.0.05  2.3 3.2 3.1 1.05 1.7 2.5 2.6

Table 6: Total glucosinolates content (µ mol/g dry weight) and total phenolics (mg/g dry weight) in the extracts of the seed powder of both watercress and mustard.

| Seed powder extracts of | Total content of glucosinolates (µ mol/g dry weight) | Total content of phenolic compounds (mg/g dry weight) |
|-------------------------|--------------------------------------------------------|------------------------------------------------------|
| Watercress              | 316.03                                                 | 35.62                                                |
| Mustard                 | 288.59                                                 | 43.62                                                |

There is no doubt that the results of this work as well as our previous results showed clearly the possibility of using the seed powder of watercress or mustard as a successful tool for decreasing the weeds seed bank in the soil and also add more support to the idea of using the vegetative parts of the two mentioned plants as a cover crop on weed dynamics to subsequent cultivation (Jabran et al., 2015). Therefore, it is recommended to start controlling weeds associated with a certain crop from the previous crop cultivation season.
4. Conclusion

We predict the possibility of using the seed powder of watercress or mustard as a powerful tool in controlling weeds and definitely decreasing the weed seed bank for the next crop. Therefore, more attention must be paid for the possibility of using the vegetative parts of the two mentioned plants as a cover crop on weed dynamics in subsequent cultivation. Moreover, weed control should start in the previous crop by monitoring, controlling and managing the weeds. This means that Brassicaceae family could be considered as a wise application of controlling weeds.

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