allelepathic potential of Capsicum Annuum L. and Coriandrum Sativum L. on growth of bean crop

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Abstract: Allelochemical are natural compounds which effects the growth of surrounding plants. The treatment of aqueous powder extracts of Capsicum annuum L. and Coriandrum sativum L. at 1% showed significant decreased in shoot, root and seedling height, leaves growth and biomass of mung bean (Vigna radiata). The inhibitory effect on growth performance was directly related with the increasing concentration of powder extracts of coriander. The seedlings of both legume bean were tested for the determination of toxicity and tolerance to red chili and coriander powder extract treatment at 0, 1, 2, 3, 4 and 5%. The seedlings of mung bean and cowpea showed lowest percentage of tolerance indices to coriander and red chilli powder extract treatment at 5%. However, on comparison, the seedlings of cowpea showed more tolerance to coriander and red chili powder extract than mung bean.

Keywords: coriander, phytotoxicity, plant extracts, red chili, root growth, seedling growth, tolerance indices.

Introduction

The discharge of phytochemical substances from one plant species altered the growth performances of surrounding plants. Many studies have shown that the release of toxic substances by a plant decreased or promote growth of neighboring plants [Chou & Lee, 1991; Kil & Yun, 1992; Reinhardt & al. 1993; Alloli & Narayanreddy, 2000; Daizy & al. 2001; Ferguson & Rathinaspabathi, 2003; Oussama, 2003; Dongre & Yadav, 2005; Mishra & al. 2014] and termed as allelopathy. The impact of leaf leachates of some woody plant species on agriculture and some desert plants were reported [Melkania, 1984; Hegazy & al. 1990; Puri & Khara, 1991]. Seed regeneration failures of Pinus silvestris L. by Empetrum hermaphroditum Hagerup occurred due to allelopathic interference [Zackrissone & Nilsson, 1992].

Allelopathy helps in ecosystems management [Abbassi & al. 2013] and some work in early 1970 was initiated in Pakistan [Cheema & al. 2013]. These chemicals products can serve for weed control [Bagheri & al. 2013; Bojovic & Jakovljevic, 2015]. The release of allelopathic compounds influence positively and negatively on the growth of plants. Capsicum annuum L. belongs to Solanaceae family. Coriandrum sativum L. (Apiaceae) is popular medicinal plant and seeds are source of iron, copper, calcium, magnesium and zinc. Both spices production have great economic demands and used in cooking on daily basis in Pakistan and worldwide.

The purpose of the studies was to assess the toxic potential of red chili and coriander aqueous powders extract on the growth of two different bean crops namely, cowpea and mung bean because of economic importance of both leguminous crops are cultivating in the larger agricultural area of the Pakistan.
Material and methods

The experimental site is located in the Department of Botany at the Karachi University Campus and seedling growth experiment was carried out in pots in green house. 1% solution of red chilli or coriander powder prepared by weighing one g of spice powder then dissolve in 99 ml of distilled water to make up the volume up to 100 ml and subsequent concentrations 1%, 2%, 3%, 4% and 5% were prepared respectively. The fruit of red chilli and seeds of coriander powder was kept in boiling so that convert into solution completely. The certified seeds of cowpea and mung bean were purchased from market and imbibed in water for an hour to break seed dormancy. The beans seeds surface was sterilized with 1N bleach solution for three minutes and rinsed by distilled water to remove any type of fungal contamination. The plastic pots were 7.3 cm in diameter and 9.6 cm in depth and were filled with ratio of one-part manure and three parts garden loam. Dig 1 cm holes of soil from above the surface of pots, at least 5 holes and buried the 2-2 seeds of one type of plant into pot. The pots were water daily and under the influence of sunlight, seeds were able to germinate uniformly in two weeks. One seedling was grown in each pot and ten ml of powder extract of *Capsicum annuum* L. and *Coriandrum sativum* L. were provided into the respective pots. The experiment was completely randomized. The pots were reshuffled weekly to avoid light, shade or any other climatic factors. There were five replicates of each treatment. The seedlings were uprooted from the pots after five weeks and washed with tap water. The root, shoot and seedling length and numbers of leaves were recorded. The removed seedlings were kept in oven at 80 °C for 24 hours for the determination of dry weight. Root, leaf, shoot and total plant fresh and dry weight were recorded. Root / shoot ratio, leaf weight, specific leaf area and leaf area ratio were determined according to REHMAN & IQBAL (2009).

The obtained data was statistically analyzed by ANOVA and DMRT (Duncan Multiple Range Test) (p  < 0.05) using software packages SPSS version 14.0 on personal computer.

Results

The treatment of different concentrations of red chilli and coriander aqueous powder extract showed variable effects on growth performance of cowpea and mung bean (Table 1-4). Red chilli extract treatment at 4% significantly (p<0.05) decreased root, shoot, seedling height, leaf area and total fresh weight of cow pea. The significant decline in leaf weight ratio of cow pea was found at 3% red chilli extract treatment. The treatment of red chilli powder extract at 3% was brought a significant decrease in shoot growth, number of leaves and leaves dry weight of mung bean. The treatment of red chilli at all concentration showed nonsignificant effect on root, shoot dry weight and specific leaf area of cow pea, whereas, root fresh weight and root shoot ratio of mung bean. Shoot, root, seedling length, number of leaves and leaf size of cow pea was highly decreased at 5% coriander aqueous powder extract treatment. Coriander extract treatment at 1% treatment produced significantly lower number of leaves in mung bean. The coriander extract treatment at 5% significantly affected root, shoot and total plant dry weight of mung bean. Leaf weight ratio, of mung bean greatly affected by 5% of coriander powder extract treatment.
Table 1. Growth of cowpea in various concentrations of red chilli powder extract.

| Seedling growth characteristic | Treatments aqueous powder extract concentration (%) |
|-------------------------------|-----------------------------------------------|
|                               | 0      | 1      | 2      | 3      | 4      | 5      |
| Shoot length (cm)             | 69.31 f | 68.86 e | 66.67 d | 66.56 c | 60.32 b | 60.00 a |
| Root length (cm)              | 12.75 f | 12.05 e | 10.80 d | 9.87 c  | 9.50 b  | 8.27 a  |
| Seedling length (cm)          | 82.05 f | 80.91 e | 77.47 d | 76.43 c | 69.82 b | 68.27 a |
| Number of leaves              | 15.00 ae| 13.66 d | 12.33 d | 12.00 bc| 11.00 ab| 10.33 a |
| Leaf area (cm$^2$)            | 48.65 d | 42.91 d | 38.00 c | 35.33 b | 35.58 b | 30.85 a |
| Root fresh weight (g)         | 0.880 d | 0.860 d | 0.800 c | 0.640 b | 0.620 b | 0.440 a |
| Shoot fresh weight (g)        | 1.72 e  | 1.42 d  | 1.34 c  | 1.33 c  | 1.02 b  | 0.850 a |
| Leaves fresh weight (g)       | 1.15 d  | 1.01    | 0.870 bc| 0.640 ab| 0.620 ab| 0.440 a |
| Total plant fresh weight (g)  | 3.30 d  | 2.990 c | 2.350 c | 2.11 bc | 1.890 ab| 1.760 ab|
| Root dry weight (g)           | 0.180 a | 0.190 a | 0.310 a | 0.170 a | 0.120 a | 0.100 a |
| Shoot dry weight (g)          | 0.850 e | 0.720 d | 0.660 c | 0.680 c | 0.520 b | 0.310 a |
| Leaves dry weight (g)         | 0.280 a | 0.260 a | 0.250 a | 0.240 a | 0.185 a | 0.100 a |
| Total plant dry weight (g)    | 2.180 b | 2.020 ab| 1.510 a | 1.210 a | 0.980 a | 0.780 a |
| Root / Shoot ratio            | 0.297 b | 0.246 a | 0.350 a | 0.310 a | 0.316 ab| 0.320 a |
| Leaf weight ratio             | 0.450 ab| 0.280 ab| 0.220 a | 0.230 a | 0.310 b | 0.340 b |
| Specific leaf area (cm$^2$ g$^{-1}$) | 23.260 a| 38.930 a| 43.270 a| 53.190 a| 37.540 a| 47.160 a|
| Leaf area ratio (cm$^2$ g$^{-1}$) | 10.450 c| 10.990 c| 9.910 a | 12.620 b| 11.800 d| 11.550 e |

Number followed by the same letters on the same column are not significantly different (p<0.05) according to Duncan’s Multiple Range Test. Symbol used: ± = Standard error.
Table 2. Growth of mung bean in various concentrations of red chilli powder extract.

| Seedling growth characteristic | TREATMENTS aqueous powder extract concentration (%) |
|--------------------------------|---------------------------------------------------|
|                                | 0       | 1       | 2       | 3       | 4       | 5       |
| Shoot length (cm)              | 48.21 a | 44.13 e | 43.00 d | 42.81 c | 42.33 b | 40.23 b |
|                               | ± 0.048 | ± 0.041 | ± 0.025 | ± 0.020 | ± 0.213 | ± 0.052 |
| Root length (cm)               | 12.43 a | 10.96 e | 11.37 c | 11.00 d | 8.060 d | 6.900 b |
|                               | ± 0.094 | ± 0.251 | ± 0.094 | ± 0.001 | ± 0.043 | ± 0.231 |
| Seedling length (cm)           | 60.64 b | 55.09 a | 54.37 b | 53.81 b | 50.39 b | 47.13 b |
|                               | ± 0.140 | ± 0.029 | ± 0.071 | ± 11.767| ± 0.172 | ± 0.273 |
| Number of leaves               | 10.00 a | 8.660 c | 8.000 b | 7.870 ab| 7.510 b | 7.120 a |
|                               | ± 0.001 | ± 0.249 | ± 0.002 | ± 0.462 | ± 0.231 | ± 0.241 |
| Leaf area (cm²)                | 22.80 a | 21.45 e | 20.45 d | 20.30 c | 18.00 b | 17.00 b |
|                               | ± 0.218 | ± 0.114 | ± 0.085 | ± 0.091 | ± 0.001 | ± 0.002 |
| Root fresh weight (g)          | 0.390 a | 0.360 a | 0.230 a | 0.210 a | 0.100 a | 0.090 a |
|                               | ± 0.009 | ± 0.004 | ± 0.013 | ± 0.006 | ± 0.223 | ± 0.004 |
| Shoot fresh weight (g)         | 1.630 a | 1.410 e | 1.400 d | 1.210 d | 1.150 c | 1.010 b |
|                               | ± 0.165 | ± 0.006 | ± 0.005 | ± 0.013 | ± 0.004 | ± 0.006 |
| Leaves fresh weight (g)        | 1.280 b | 0.520 e | 0.720 a | 0.690 d | 0.640 c | 0.620 b |
|                               | ± 0.021 | ± 0.006 | ± 0.002 | ± 0.004 | ± 0.004 | ± 0.005 |
| Total plant fresh weight (g)   | 3.300 a | 2.290 c | 2.350 b | 2.110 b | 1.890 b | 1.720 ab|
|                               | ± 0.019 | ± 0.011 | ± 0.011 | ± 0.017 | ± 0.229 | ± 0.006 |
| Root dry weight (g)            | 0.170 a | 0.150 bc| 0.190 b | 0.160 c | 0.040 b | 0.020 a |
|                               | ± 0.004 | ± 0.004 | ± 0.004 | ± 0.004 | ± 0.006 | ± 0.017 |
| Shoot dry weight (g)           | 1.030 a | 1.010 e | 0.640 f | 0.410 d | 0.350 c | 0.210 b |
|                               | ± 0.004 | ± 0.006 | ± 0.004 | ± 0.004 | ± 0.008 | ± 0.002 |
| Leaves dry weight (g)          | 0.980 a | 0.860 f | 0.680 e | 0.590 c | 0.550 b | 0.780 b |
|                               | ± 0.004 | ± 0.004 | ± 0.004 | ± 0.008 | ± 0.004 | ± 0.220 |
| Total plant dry weight (g)     | 2.180 b | 2.020 ab| 1.510 a | 1.210 a | 0.980 a | 0.780 a |
|                               | ± 0.428 | ± 0.220 | ± 0.070 | ± 0.039 | ± 0.041 | ± 0.020 |
| Root / Shoot ratio             | 0.297 a | 0.291 a | 0.304 a | 0.296 a | 0.216 a | 0.192 a |
|                               | ± 0.004 | ± 0.043 | ± 0.002 | ± 0.020 | ± 0.028 | ± 0.006 |
| Leaf weight ratio              | 0.450 a | 0.425 a | 0.450 a | 0.450 ab| 0.602 a | 0.705 b |
|                               | ± 0.001 | ± 0.011 | ± 0.001 | ± 0.004 | ± 0.051 | ± 0.014 |
| Specific leaf area (cm² g⁻¹)   | 23.260 a | 24.900 b| 30.070 c| 31.710 d| 30.500 c| 30.900 c|
|                               | ± 0.242 | ± 0.095 | ± 0.052 | ± 0.100 | ± 0.097 | ± 0.176 |
| Leaf area ratio (cm² g⁻¹)      | 10.450 a | 10.610 a| 13.540 b| 16.770 c| 18.360 d| 21.790 e|
|                               | ± 0.069 | ± 0.112 | ± 0.070 | ± 0.155 | ± 0.184 | ± 0.154 |

Number followed by the same letters on the same column are not significantly different (p<0.05) according to Duncan’s Multiple Range Test. Symbol used: ± = Standard error.
Table 3. Growth of cowpea in various concentrations of coriander powder extract.

| Seedling growth characteristic | Treatments aqueous powder extract concentration (%) | 0       | 1       | 2       | 3       | 4       | 5       |
|-------------------------------|---------------------------------------------------|---------|---------|---------|---------|---------|---------|
|                               |                                                   | 0       | 1       | 2       | 3       | 4       | 5       |
| Shoot length (cm)             |                                                   | 69.30 f | 65.87 d | 64.56 c | 68.92 e | 62.18 b | 57.00 a |
|                               |                                                   | ± 0.040 | ± 0.067 | ± 0.157 | ± 0.195 | ±0.008  | ±0.278  |
| Root length (cm)              |                                                   | 12.75 c | 10.80 b | 15.05 e | 12.80 c | 13.65 d | 8.60 a  |
|                               |                                                   | ± 0.16  | ± 0.040 | ± 0.012 | ± 0.173 | ±0.167  | ±0.040  |
| Seedling length (cm)          |                                                   | 82.05 f | 76.67 c | 79.61d  | 81.72 e | 75.83 b | 65.60 a |
|                               |                                                   | ± 0.022 | ± 0.154 | ± 0.030 | ± 0.150 | ±0.011  | ±0.086  |
| Number of leaves              |                                                   | 15.00 e | 10.30 b | 10.23 b | 12.66 d | 11.00 c | 9.00 a  |
|                               |                                                   | ± 0.00  | ±0.230  | ±0.020  | ±0.230  | ±0.010  | ±0.001  |
| Leaf area (cm²)               |                                                   | 48.65 d | 40.38 c | 46.00 d | 40.41 c | 30.33 b | 22.16 a |
|                               |                                                   | ± 0.037 | ± 0.033 | ± 0.040 | ±0.004  | ±0.008  | ±2.736  |
| Root fresh weight (g)         |                                                   | 0.88 b  | 0.930 c | 0.820 a | 1.00 d  | 0.950 c | 0.810 a |
|                               |                                                   | ± 0.004 | ± 0.004 | ± 0.004 | ± 0.002 | ±0.004  | ±0.004  |
| Shoot fresh weight (g)        |                                                   | 1.72 d  | 1.73 d  | 1.44 c  | 1.41 c  | 1.28 b  | 1.140 a |
|                               |                                                   | ± 0.013 | ± 0.008 | ± 0.008 | ± 0.004 | ±0.020  | ±0.008  |
| Leaves fresh weight (g)       |                                                   | 1.15 d  | 0.970 ab| 0.950 bc| 0.850 ab| 0.720 ab| 0.610 a |
|                               |                                                   | ± 0.009 | ± 0.212 | ± 0.014 | ±0.144  | ±0.004  | ±0.008  |
| Total plant fresh weight (g)  |                                                   | 3.30 c  | 3.39 bc | 3.70 bc | 3.30 bc | 3.53 b  | 2.96 a  |
|                               |                                                   | ± 0.115 | ± 0.206 | ± 0.122 | ±0.171  | ±0.149  | ±0.038  |
| Root dry weight (g)           |                                                   | 0.220 a | 0.210 a | 0.300 a | 0.240 a | 0.200 a | 0.180 a |
|                               |                                                   | ± 0.400 | ± 0.004 | ± 0.005 | ±0.008  | ±0.004  | ±0.010  |
| Shoot dry weight (g)          |                                                   | 0.210 d | 0.130 b | 0.200 d | 0.150 a | 0.130 c | 0.160 a |
|                               |                                                   | ± 0.012 | ± 0.007 | ± 0.018 | ±0.015  | ±0.008  | ±0.004  |
| Root / Shoot ratio            |                                                   | 0.180 a | 0.230 c | 0.220 bc| 0.200 ab| 0.300 d | 0.270 c |
|                               |                                                   | ± 0.005 | ± 0.001 | ± 0.003 | ±0.009  | ±0.010  | ±0.008  |
| Leaf weight ratio             |                                                   | 0.850 d | 0.880 d | 0.740 c | 0.610 b | 0.800 d | 0.590 a |
|                               |                                                   | ± 0.004 | ± 0.004 | ± 0.005 | ±0.012  | ±0.034  | ±0.007  |
| Specific leaf area (cm² g⁻¹)  |                                                   | 0.280 d | 0.170 b | 0.250 c | 0.180 b | 0.170 ab| 0.170 a |
|                               |                                                   | ± 0.002 | ± 0.002 | ± 0.010 | ±0.004  | ±0.002  | ±0.004  |
| Leaf area ratio (cm² g⁻¹)      |                                                   | 2.180 c | 2.30 c  | 2.400 c | 1.98 b  | 1.94 b  | 1.510 a |
|                               |                                                   | ± 0.007 | ± 0.244 | ±0.027  | ±0.023  | ±0.012  | ±0.012  |

Number followed by the same letters on the same column are not significantly different (p<0.05) according to Duncan’s Multiple Range Test. Symbol used: ± = Standard error.

Table 4. Growth of mung bean in various concentrations of coriander powder extract.

| Seedling growth characteristic | Treatments aqueous powder extract concentration (%) | 0       | 1       | 2       | 3       | 4       | 5       |
|-------------------------------|---------------------------------------------------|---------|---------|---------|---------|---------|---------|
|                               |                                                   | 0       | 1       | 2       | 3       | 4       | 5       |
| Shoot length (cm)             |                                                   | 48.21 e | 45.31 b | 45.42 c | 46.13 d | 46.22 b | 40.23 a |
|                               |                                                   | ± 0.008 | ± 0.004 | ± 0.029 | ± 0.010 | ±0.027  | ±0.016  |
| Root length (cm)              |                                                   | 12.43 c | 13.37 de| 11.90 a | 12.30 c | 12.33 c | 6.90 b  |
|                               |                                                   | ± 0.020 | ± 0.010 | ± 0.040 | ± 0.062 | ±0.009  | ±0.016  |
| Seedling length (cm)          |                                                   | 60.64 e | 56.68 d | 57.32 b | 58.43 c | 58.55 c | 47.13 a |
|                               |                                                   | ± 0.014 | ± 0.014 | ± 0.056 | ± 0.057 | ±0.030  | ±0.029  |
| Number of leaves              |                                                   | 10.00 b | 8.35 a  | 9.00 b  | 10.12 b | 9.66 b  | 7.22 b  |
|                               |                                                   | ± 0.00  | ± 0.781 | ± 0.00  | ± 0.409 | ±0.034  | ±0.001  |
| Leaf area (cm²)               |                                                   | 22.80 a | 22.97 ab| 23.80 b | 25.00 c | 22.90 a | 17.00 c |
|                               |                                                   | ± 0.080 | ± 0.040 | ± 0.080 | ±0.062  | ±0.022  | ± 0.81  |
The seedlings of cowpea were tested to the tolerance to different concentrations of red chilli and coriander powder extract. Red chilli extract treatment at 1, 2, 3, 4 and 5% gradually decreased tolerance indices by 94.50, 84.70, 77.41, 74.50 and 65.79% in seedlings of cowpea. The treatment of coriander extract treatment at 5% showed the lowest tolerance (67.45%) indices. However, on comparison, the seedlings of cowpea showed more tolerance to coriander powder extract than red chilli extract at 5%. Red chilli extract treatment at 4 and 5% showed tolerance indices by 64.84 and 55.51% in seedlings of mung bean. Coriander extract treatment at all concentrations showed better tolerance in seedlings of mung bean as compared to red chilli extract at similar concentrations.

Discussion

The studies on interactions and competition for resources among plants was carried out and suggested for the use in modifying the pattern of crop cultivation and for the increase in yields [MAJEED & al. 2017]. The treatment of red chili and coriander aqueous powder extract influenced on seedling growth performances of cowpea and mung bean. The agrochemical groups are naturally occurred in plant [KUTI & al. 1990] and produced favorable and toxic impact on the growth of surrounding plants. It was found that the release of chemical compounds from both home spices in the given substrate affected growth performance of both beans. The different response in seedling growth parameters of bean seems attributable to the level of red chili and coriander powder extract treatments. Allelopathic compounds from plants residues called allelochemicals and may work as inhibitor or beneficial for growth of subsequent plants [RICE, 1984]. The maximum
inhibitory allelopathic effect of bindweed (Convolvulus arvensis L.) vegetative part at 10% on seed vigor index for millet and basil plants was observed [FATEH & al. 2012]. The inhibitory substances from C. annuum and C. sativum released in the soil which apparently showed allelopathic potential and might be cause for significant decline in growth characteristics of cowpea and agreed with the findings of ELLS & MCSAY (1991) on cucumber seedlings by alfalfa plant residues. Capsaicin have a powerful allelopathic effect on growth of plant [CHO & al. 1992] and growth of weed [GONZALEZ & al. 1997]. The treatment of both spices at 2% level further decreased root and shoot growth of cowpea. MOOSAVI & al. (2011) also found significantly decreased in shoot and root growth of Vigna radiata L. with aqueous extract of leaf, stem and root of sorghum. The treatment of coriander powder extract showed beneficial and harmful effects on the seedling characteristics of cowpea. The low concentration of coriander powder at 1% slightly increased and a higher concentration decreased the seedling dry weight of cowpea. The presence of phenols and tannins from Jatropha curcas (5-20%) as allelochemicals showed inhibitory effect on green chilli and stimulatory on sesame [REJILA & VIJAYAKUMAR, 2011].

Conclusions

It was concluded that aqueous powder extract of red chili and coriander at 5% influenced on seedling growth and tolerance index of cowpea and mung bean. The availability of toxic allelochemicals compounds from both spices in substrate showed strong allelopathic potential activity for seedling of cowpea and mung bean.

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Acknowledgements

The authors sincerely acknowledged the experimental facilities provided by the Chairman, Department of Botany, University of Karachi.

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How to cite this article:

IQBAL M. Z., AHMED L. & SHAFAQ M. 2020. Allelopathic potential of Capsicum annuum L. and Coriandrum sativum L. on growth of bean crop. J. Plant Develop. 27: 63-70. https://doi.org/10.33628/jpd.2020.27.1.63