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Allelopathic Influence of Alfalfa and Vetch Extracts and Residues on Soybean and Corn

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알팔파와 베치의 추출물 및 잔유물의 콩과 옥수수에 대한 타감작용

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ABSTRACT : Greenhouse and laboratory studies were conducted to investigate the allelopathic potential of alfalfa and vetch residues on soybean and corn using various extract concentrations (0, 5, 10, 15 and 20%, w/v) and residue rates (0, 0.25, 0.5, 0.75 and 1%, w/w). Aqueous extracts of alfalfa (*Medicago sativa* L.) and vetch (*Vicia* spp.) exhibited an allelopathic effect on soybean and corn seed germination, seedling length and weight. The degree of inhibition significantly increased as the aqueous extract concentration increased. Alfalfa and vetch 20% extracts reduced soybean seed germination, seedling length and weight by 35%, 57%, 32% and 15%, 42%, 25% respectively, when compared to control. Corn germination, seedling length and weight was inhibited by 20%, 23%, 38% by alfalfa and 19%, 18%, 35% by 20% vetch extracts. Alfalfa and vetch extracts inhibited secondary root formation and branching as the extract concentration increased. Alfalfa and vetch 20% extracts inhibited by 41% and 32% secondary root numbers, respectively as compared to control. It was found that the aqueous extract of alfalfa resulted in greater reduction in germination, seedling length and weight of soybean than that of vetch.

Alfalfa and vetch 1% residue rate inhibited soybean plant height by 30% and 10%, leaf area by 31% and 23%, and dry weight by 18% and 1%, nodule number by 27% and 20% also. Alfalfa and vetch residue significantly enhanced plant height, leaf area and dry weight of corn. The maximum stimulation occurred with 0.25% and 1% of alfalfa and vetch residue rates, respectively. Plant height, leaf area, and dry weight increased by 23%, 59%, 58% and 17%, 52%, 94% with alfalfa and vetch residues of 0.25% and 1%, respectively. This study demonstrates that there is an allelopathic potential resulting from alfalfa and vetch residues on soybean growth and yield. It also suggests that these residues may affect crop growth and development due to the inhibitory or stimulatory effects of allelochemicals existing in the residue.

Key word : Soybean, Corn, Allelopathic effect, Alfalfa, Vetch, Residue rate, Seedling growth

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Allelopathy, any direct or indirect effect of one plant on another through the production and release of toxic substances into the environment, exists among weeds and crops[17]. A type or form of allelopathy in agriculture, autotoxicity, is that some toxic substances from plants may cause intra-species effects. Reduced yields are commonly related to old alfalfa stands, especially when alfalfa is planted directly after an old stand is plowed under. Reports of such autotoxicity occurrences are numerous[3,6,7,12]. Guenzi, et al[3] reported that alfalfa contains water soluble substances that are toxic to itself and to other plants. Water extracts from alfalfa top growth and roots inhibit corn seed germination, and the root leachate is more inhibitory.

The allelopathic effect of alfalfa is an important concern since it is related to crop rotation. Under limited rotation of cropping in Central Alberta, Canada, alfalfa was unsuccessfully re-established[19]. They also observed typical plant symptoms as being dwarfed, spindly, yellowish green plants with irregular brown-reddish to dark brown lesions on the top and lateral roots and a few ineffective nodules.

Crop yield reduction is often observed when grown in rotation with alfalfa, for crops such as wheat, corn, soybeans and sorghum. Miller[10] reported that the best preceding crop for alfalfa establishment is corn, followed by various small grain crops or soybean, while the worst preceding crop is alfalfa.

Also use of cover-crops such as hairy vetch, rye, and wheat is a very effective method for controlling soil erosion. Thus, properly managed cover-crop may be utilized as an additional component in crop management strategies for no-till cropping systems.

The increase in no-till and conservation tillage for crop production has increased the importance of identification of allelopathic interactions resulting from the release of phytotoxic chemicals during residue decomposition[2,9,13,14].

Many legume crops contain secondary plant products that have allelopathic potential. Patrick et al[13] reported when using lettuce as a bioassay, the presence of phytotoxic substances in the decomposition products of vetch extract. White et al[21] reported inhibition of some crops from residues and leachates of crimson clover and hairy vetch. When hairy vetch and crimson clover debris were mixed with soil, cotton and pitted morningglory emergence and dry weight decreased 60 to 80%. Conversely, corn dry weight was stimulated 20 to 75% when legume residues were left on the soil surface. Thus the potential for allelochemical production exists in legumes such as crimson clover and hairy vetch. Also, Weston and Putnam[20] reported that decrease in legume like soybean, navybean, pea growth and nodulation by the presence of quackgrass may be attributed to allelochemicals effects.

This study investigated the long term allelopathic effects of alfalfa and vetch residues on soybean, and corn seed germination and growth since alfalfa is usually planted in rotation with soybean and corn. Vetch has been used more recently for soil conservation and erosion control. Laboratory trials were conducted to evaluate the effect of aqueous extracts of alfalfa, and vetch on germination and seedling vigor of soybean and corn as well as alfalfa, and vetch residues in a growing media on soybean and corn in the greenhouse.

Materials and Methods

1. Collection and preparation of residue

Alfalfa and vetch plants were harvested at the vegetative stage. Samples were air-dried at room temperature (24℃) for three weeks, and then ground in a Wiley mill to pass through a 40 mesh screen. Ground samples were stored in plastic bottles in a cold room of 5℃ temperature until using.

2. Preparation of the aqueous extracts

A bioassay experiment was conducted with aqueous extracts of alfalfa, and vetch in oblong dishes (32.0×22.0 cm). 5, 10, 15, and 20g of the ground materials were weighed separately and put in 250ml volumetric flasks with 100ml distilled water. These were designated as 5, 10, 15, and 20%(w/v) aqueous extracts and held at room temperature for 24h by soaking. Extracts were filtered through filter paper (Whatman No. 42) and 0.2μm Nalgene filter ware unit (Becton Dickinson Labware, Lincoln Park, NJ). The pH of the extracts was determined with a Beckman pH meter and electrical conductivity of the extracts was measured using a model 31−YSI conductivity bridge and seedling growth.

3. Bioassay study

Seeds of soybean (Williams 82) and corn (Pioneer 3572F14) were sterilized in 1% sodium hydrochlorite for 5 minutes and then rinsed several times with distilled water. Sixty soybean and thirty-five corn seeds were placed in heat sterilized oblong dishes with three sheets of germination paper moistened with 25ml of each extract and covered with two germination papers. Distilled water was used as a control. The oblong dishes were then placed in a lighted room at 24℃. Seed germination was counted every day for 5 days at 24h time intervals. Rate of germination was calculated by dividing the number of germinating seed each day by the number of days and summing the values[8]. Seeding vigor (SV) was calculated by multiplying total seed germination and radicle length[18]. To prevent seedling curling and morphological change, thin layer chromatography (TLC) tanks were used for seedling measurement. Twenty soybean and corn seeds were wrapped with two sheets of germination paper. These were placed into sterilized TLC tanks of the same concentration as the germination test and then, covered to avoid losing moisture. Length of radicle and hypocotyl, and dry weight of seedling were measured 6d after the initiation of the study. When measuring secondary roots, radicles over 10mm length were counted as secondary roots. Ten plants were randomly measured from each tank. Each extract treatment was replicated five times in a completely randomized design and the experiment was repeated three times using alfalfa and four times using vetch.

4. Greenhouse study by residue rate

Residue rate experiments were conducted in the greenhouse with an average temperature of 24℃. The photosynthetic photon flux density (PPFD) during illumination was 530μmol photon $m^{-2}s^{-1}$. Sunlight was supplied with incandescent lights to give a 16h photoperiod. Residue rates (w/w) were at 0, 0.25, 0.5, 0.75 and 1.0%. The control plants were grown in silica sand with no residue. Residues were incorporated thoroughly into the growing media and placed into pot. Each pot contained 1000 g silica sand. Eight surface sterilized corn seeds and soybean were planted 2.5cm deep in each pot. Each pot was placed on a pot saucer and

Hoagland solution I[5] was supplied daily on the saucer. After emergence, seedlings were thinned to five plants per pot. All plants were harvested 24 days after planting (DAP). Plant height was measured using the highest extended leaf. The leaves were separated from the shoot, and leaf area (LA) was measured by automatic area meter[1]. The leaves and shoots were oven-dried at 85℃ for 6h and dry weights were recorded.

5. Influence on soybean nodule number

The following experiments were conducted to determine if nodulation is inhibited by the presence of alfalfa and vetch residue. Soils were collected from a field where alfalfa and vetch had grown the previous 4 years. Residue rates (w/w) of alfalfa and vetch were at 0, 0.25, 0.5, 0.75 and 1.0%, respectively. The control plants were grown with no residue. Residues were incorporated thoroughly into the growing media and placed into pot. Each pot contained 2000g soil. Sample soil analysis exhibited a pH of 6.55, 4216kg K, 5815kg Ca, 1712kg Mg/ha. Eight surface sterilized-soybean seeds were planted 2.5cm deep in each pot. After emergence, seedlings were thinned to five plants per pot. Soybean was harvested 35 DAP. Nodule number for five plants per pot was counted after root systems were carefully extracted from the soil and gently washed. Above two experiments were arranged in a completely randomized design and the experiment repeated twice with three replications. Results are reported as an average. The pooled mean values were separated by the least significant difference (LSD) at the 0.05 probability level.

Results

1. Bioassay study

Soybean and corn seed germination percentage and seedling radicle and hypocotyl length, and cotyledons, hypocotyl, and radicle weight as affected by aqueous extracts of alfalfa and vetch are presented in Tables 1, 2, 3 and 4. As the alfalfa and vetch aqueous extracts concentrations increased soybean and corn germination percentage was inhibited.

Compared to the control, aqueous extracts of increasing concentrations of alfalfa showed a significant inhibition of soybean germination (Table 1). The maximum germination inhibition occured at the highest extract concen-

Table 1. The effect of various dried alfalfa extract concentrations on germination, seedling growth and weight, seedling vigor, and germination rate of soybean

Concentration(%)	GP[1]	RL[1]	HL[1]	CW[1]	HW[1]	RW[1]	SV[1]	GR[1]
	… % …	………… cm	…………	……………… mg		………………		
0	93.3	16.2	10.9	144.8	24.2	12.0	1516.2	38.36
5.0	84.0	9.0	9.4	125.7	23.7	8.7	757.7	32.57
10.0	78.3	9.0	8.5	114.1	16.1	7.2	700.6	28.21
15.0	75.6	6.7	7.9	108.2	18.8	6.4	505.6	21.95
20.0	61.0	5.7	6.2	106.6	13.6	3.7	348.2	17.42
LSD (0.05)	4.95	1.02	1.44	6.36	2.98	1.52	98.63	2.09
CV (%)	4.78	8.36	12.78	4.02	11.74	15.15	9.76	5.73

[1]GP, Germination percentage; RL, Radicle length; HL, Hypocotyl length; CW, Cotyledons weight; HW, Hypocotyl weight; RW, Radicle weight; SV, Seedling vigor; GR, Germination rate.

[1] TYPE AAM5, Tokyo Hayashi Denco., Ltd., Japan.

tration. Total germination of seed treated with distilled water (control) was 93%. The aqueous extracts of vetch up to 15% concentration showed no inhibitory effect on soybean germination (Table 2).

However, 20% extract of vetch significantly reduced soybean germination. Germination inhibition was concentration dependent with the maximum 20 % aqueous extract of alfalfa and vetch having a total germination of 61 %, and 80% respectively. Compared to the 20% extract rate, germination was inhibited less by 15 % and 10% extracts in descending order. Aqueous extracts of alfalfa had no significant effect on germination at the lowest extract concentration (5%).

Germination percentage of corn was statistically simillar for 10, 15 and 20% extracts (Table 3). The effect of vetch on the corn germination was not significant between the control and 5%, and 10% extract treatments (Table 4). However, germination rate responded differently between the control and other treatments. The 20% extract of vetch caused severe reduction of corn germination.

In general, reduction of soybean and corn germination was greater with alfalfa aqueous extracts than with vetch. The 20% aqueous extracts of alfalfa and vetch reduced seed germination of soybean by 35% and 15%, respectively, and the same concentrations inhibited corn germination by 19% and 20%, respectively.

Seedling (radicle + hypocotyl) length of

Table 2. The effect of various dried vetch extract concentrations on germination, seedling growth and weight, seedling vigor, and germination of rate soybean

Concentration(%)	GP[1]	RL[1]	HL[1]	CW[1]	HW[1]	RW[1]	SV[1]	GR[1]
	… % …	………… cm	…………	………………	mg	………………		
0	93.3	16.2	10.9	144.8	24.2	12.0	1516.2	64.47
5.0	93.0	12.6	10.0	129.3	24.5	9.0	1168.2	59.47
10.0	90.3	12.6	10.0	129.3	24.5	9.0	1168.2	59.47
15.0	90.3	11.0	9.2	122.9	17.0	7.4	993.2	52.61
20.0	79.7	9.1	6.7	118.0	14.7	4.6	720.2	37.42
LSD (0.05)	9.06	0.99	1.30	7.49	2.95	1.41	143.26	2.76
CV (%)	7.70	6.32	10.82	4.43	11.51	13.67	10.13	6.63

[1]GP, Germination percentage; RL, Radicle length; HL, Hypocotyl length; CW, Cotyledons weight; HW, Hypocotyl weight; RW, Radicle weight; SV, Seedling vigor; GR, Germination rate.

Table 3. The effect of various dried alfalfa extract concentrations on germination, seedling growth and weight, seedling vigor, and germination rate of corn

Concentration(%)	GP[1]	RL[1]	HL[1]	CW[1]	HW[1]	RW[1]	SV[1]	GR[1]
	… % …	………… cm	…………	………………	mg	………………		
0	90.2*	23.1	7.8	58.0	61.5	2087.0	11.09	6.8
5.0	84.6	18.4	8.7	59.0	36.3	1563.8	10.09	5.6
10.0	76.0	18.0	8.4	56.8	31.5	1372.5	7.86	5.4
15.0	72.6	17.1	8.1	51.7	26.8	1246.5	7.36	4.8
20.0	72.6	16.5	7.5	49.4	25.7	1204.6	7.20	4.0
LSD (0.05)	7.34	0.90	0.80	7.61	5.06	158.64	0.85	0.83
CV (%)	7.03	3.67	7.55	10.48	10.54	8.04	7.43	11.88

[1]GP, Germination percentage; RL, Radicle length; CL, Coleoptile length; CW, Coleoptile weight; RW, Radicle weight; SV, Seedling vigor; GR, Germination rate, SRN; Secondary root number.

Table 4. The effect of various dried vetch extract concentrations on ermination, seedling growth and weight, seedling vigor, germination rate, and secondary root number of corn

Concentration(%)	GP[1]	RL[1]	HL[1]	CW[1]	HW[1]	RW[1]	SV[1]	GR[1]
	… % …	………… cm	…………	………………	mg	………………		
0	90.2	23.1	7.8	58.0	61.5	2087.0	11.09	6.8
5.0	89.1	19.3	9.1	63.4	55.0	1724.3	10.26	6.4
10.0	88.0	18.3	8.5	59.4	48.9	1609.6c	9.32	5.6
15.0	82.3	18.3	8.6	53.4	35.1	1508.8	8.66	5.2
20.0	73.1	17.7	7.9	51.8	26.9	1297.9	7.60	4.6
LSD (0.05)	6.00	1.36	0.95	8.66	4.32	144.19	0.58	0.98
CV (%)	5.38	5.35	8.66	11.47	7.21	6.64	4.72	13.08

[1]GP, Germination percentage; RL, Radicle length; CL, Coleoptile length; CW, Coleoptile weight; RW, Radicle weight; SV, Seedling vigor; GR, Germination rate, SRN; Secondary root number.

soybean was significantly reduced by alfalfa and vetch extracts (Table 1 and 2). The degree of reduction was increased as extract concentration increased. Radicle treated with aqueous extracts were shorter than those grown with distilled water.

The percent reduction in soybean radicle and hypocotyl length was 65% and 44% of the control with 20% extracts of alfalfa and vetch, respectively.

A similar trend on soybean hypocotyl length was observed with alfalfa and vetch extract treatments (Tables 1 and 2). The aqueous extracts from both plant sources reduced corn radicle growth. Extract concentrations from 5% to 20% of alfalfa and vetch significantly reduced corn radicle growth but not the coleoptile growth (Tables 3 and 4). The maximum concentration (20%) of alfalfa and vetch inhibited radicle growth by 29% and 23%, respectively. Unlike these trends, corn coleoptile length was stimulated by 12%, and 17% using alfalfa and vetch aqueous extracts, respectively. Secondary root numbers were inhibited 41%, and 32% by the 20% alfalfa and vetch extracts, respectively (Tables 3 and 4).

Also, the dry weight (cotyledons+hypocotyl+radicle) of soybean seedlings treated with alfalfa and vetch aqueous extracts were significantly reduced (Table 1). The highest degree of inhibition occurred in radicle weight. The percentage of reduction in soybean radicle dry weight was 69% and 62% using alfalfa and vetch 20% extracts when compared to the control.

In the case of corn, radicle weight was more inhibited than coleoptile weight with both aqueous extracts. The radicle dry weight of corn was also inhibited by 58% and 56% using 20% alfalfa and vetch extracts, respectively. The greatest reduction in total dry weight for both crops occurred when the aqueous extracts were prepared from alfalfa. Seedling vigor was assessed in terms of root length of the seedling after 5d of germination. The aqueous extracts of alfalfa and vetch had a tendency to inhibit the seedling vigor of soybean(Tables 1 and 2). The maximum seedling vigor inhibition on soybean was 77%, and 53% at the 20% extract concentration of alfalfa and vetch, respectively. A similar trend was also observed for the seedling vigor of corn (Tables 3 and 4). The degree of inhibition by 20% extracts of alfalfa and vetch was 43% and 38% of the control, respectively.

2. Greenhouse study by residue rate

Plant height, leaf area, stem, and leaf dry weight of soybean were significantly inhibited by various alfalfa and vetch residue rates (Tables 5, 6, 7 and 8). Alfalfa residue caused a greater reduction of soybean growth and development than that of vetch. The maximum growth inhibition resulted from the highest residue rate (1%). Alfalfa and vetch residue significantly inhibited plant height, and leaf area of soybean.

Soybean height was shorter with smaller leaf area expansion in response to treatments of alfalfa and vetch residues when compared to the no residue treatment (control). Greatest stunting was recorded as 30% reductions at the highest residues rates of alfalfa (1%). Dry stem weight of soybean did not decrease when alfalfa and vetch residue rates increased from 0.25% to 1.0%.

Increasing the residue rates from 0.25 to 1.0 % (w/w) did not increase the inhibitory effect of alfalfa and vetch on soybean stem weight, although leaf dry weight was significantly reduced by alfalfa residue. Alfalfa and vetch residue rate of 1% inhibited dry stem and leaf weight of soybean by 22% and 21%, and 23% and 12%, respectively (Tables 5 and 6). Soybean top dry weight was reduced with 1% alfalfa and vetch residue by 21% and 17%, respectively.

Unlike that of soybean, alfalfa and vetch residue significantly stimulated corn growth as the residue rate increased (Tables 7 and 8). Greatest growth stimulation of corn with alfalfa and vetch residue occured at 0.5% and 1% rate, respectively. The leaf dry weight stimulation of corn was 56% and 62% and the stem weight stimulation was 61% and 123% with alfalfa and vetch residues, respectively. Vetch residue enhanced height, dry stem and

Table 5. The effect of various dried alfalfa residue rates on growth and dry weight of soybean

Rate (%,w/w)	H[1]	LA[1]	DRSW[1]	DRLW[1]	DRTOP[1]
	cm	cm²	…………	mg	…………
0.00	38.9	63.3	124.3	150.0	274.3
0.25	32.2	51.5	111.6	133.2	244.8
0.50	31.7	51.0	106.7	131.0	237.7
0.75	30.4	49.3	103.6	120.8	224.5
1.00	27.2	43.7	97.6	118.2	215.9
LSD(0.05)	2.16	1.65	16.23	14.64	29.43
CV (%)	3.70	1.75	8.20	6.16	6.75

[1]H, Plant height; LA, Leaf area; DRSW, Dry stem weight; DRLW, Dry leaf weight; DRTOP, Dry top weight.

Table 6. The effect of various dried vetch residue rates on growth and dry weight of soybean

Rate (%,w/w)	H[1]	LA[1]	DRSW[1]	DRLW[1]	DRTOP[1]
	cm	cm²	…………	mg	…………
0.00	38.9	63.3	124.3	150.0	274.3
0.25	36.1	59.4	106.2	149.6	255.9
0.50	35.1	56.5	105.3	141.2	246.5
0.75	35.0	53.5	96.3	134.0	230.3
1.00	34.9	48.3	95.8	132.1	228.0
LSD(0.05)	3.11	0.59	16.36	8.98	17.17
CV (%)	4.76	0.58	8.51	3.49	3.82

[1]H, Plant height; LA, Leaf area; DRSW, Dry stem weight; DRLW, Dry leaf weight; DRTOP, Dry top weight.

Table 7. The effect of various dried alfalfa residue rates on growth and dry weight of corn

Rate (%,w/w)	H[1]	LA[1]	DRSW[1]	DRLW[1]	DRTOP[1]
	cm	cm²	…………	mg	…………
0.00	39.9	51.6	50.9	86.9	137.8
0.25	44.1	61.6	65.8	108.8	174.6
0.50	48.9	82.0	82.1	135.2	217.3
0.75	46.7	78.9	73.3	123.6	196.9
1.00	44.1	78.3	71.6	126.5	198.2
LSD(0.05)	3.12	1.00	4.23	16.60	19.97
CV (%)	3.83	0.78	3.38	7.85	5.93

[1]H, Plant height; LA, Leaf area; DRSW, Dry stem weight; DRLW, Dry leaf weight; DRTOP, Dry top weight.

Table 8. The effect of various dried vetch residue rates on growth and dry weight of corn

Rate (%,w/w)	H[1]	LA[1]	DRSW[1]	DRLW[1]	DRTOP[1]
	cm	cm^2	....	mg	....
0.00	39.9	51.6	50.9	86.9	137.8
0.25	39.8	70.5	84.3	127.3	211.6
0.50	40.2	72.3	99.6	139.0	238.6
0.75	45.0	77.7	106.6	133.1	239.7
1.00	46.8	78.6	113.3	140.7	267.4
LSD (0.05)	2.17	2.16	16.21	14.08	20.44
CV (%)	2.82	1.69	9.80	6.17	5.19

[1]H, Plant height; LA, Leaf area; DRSW, Dry stem weight; DRLW, Dry leaf weight; DRTOP, Dry top weight.

leaf weight of corn more than that of alfalfa.

3. Influence of soybean nodule number

Nodule numbers were significantly inhibited in the presence of alfalfa and vetch. There was a 27% and 20% reduction in nodule number when alfalfa and vetch residue was mixed at 1.0% level as compared control, respectively (Table 9). The formation of was more affected by the presence of alfalfa residue.

Discussion

The results of these studies indicate that alfalfa and vetch extracts reduced seed germination and seedling growth weight of soybeans and corn (Tables 1, 2, 3, and 4). It was found that the higher the extract concentration, the greater the inhibition of seed germination, seedling length and weight of soybean and corn.

The reduced seed germination, seedling growth, and dry weight resulting from alfalfa and vetch aqueous extracts was apparently due to its allelopathic effect. Aqueous alfalfa extracts inhibited corn more than vetch, and

Table 9. Influence of alfalfa and vetch various residue rate on nodule number of soybean grown on the greenhouse

Residue (%, w/w)	Alfalfa	Vetch
0.00	81.8	81.8
0.25	76.3	81.5
0.50	69.2	77.3
0.75	60.5	67.8
1.00	59.8	65.3
LSD (0.05)	4.92	2.63
CV (%)	4.70	2.33

soybean was more susceptible than corn to aqueous alfalfa extracts.

These results are similar to those of Nielsen et al[12] and Guenzi et al[3] Nielsen et al[12] reported that alfalfa, among other crops, caused the greatest delay in seed germination and growth of corn, soybean, and oats.

Total germination percentage, especially for the effect of vetch on soybean, does not necessarily provide an accurate measurement of the effect of a toxic substance, even if bioassay is an important and useful method in allelopathy research (Table 2). It was found that the rate of germination with distilled water was faster than seeds treated with aqueous extracts of vetch even though there were no statistical differences recognized in total germination between the control and 5, 10, and 15% extracts of vetch. The germination measurement is different from other plant measurements since germination involves a qualitative developmental response of an individual seed that occurs at a point in time, thus researchers often measure treatment effects on the total germination and the time to germinate.

The extracts of alfalfa and vetch resulted in a reduction of seedling vigor of soybean and corn (Tables 1, 2, 3 and 4). Secondary root numbers and branching were inhibited by aqueous alfalfa extracts (Tables 3 and 4). This inhibition is probably due to the presence of inhibitory substances in aqueous extracts and was not produced by microbial activity since we used 0.2 μm microwave filters and sterilized all materials involved in the bioassay. Seedling vigor ultimately reflects better seedling establishment and enhanced yield under some environmental situations. The rate of germination under a competitive situation with weeds could be a significant survival factor in the natural ecosystem.

Using aqueous alfalfa and vetch extracts, the bioassay indicates that plant tissue of alfalfa contain more water soluble allelochemicals. In comparison with pH and electrical conductivity of dried aqueous alfalfa and vetch extracts, i. e., a lower pH and a higher electrical conductivity in alfalfa extract suggested that the two extracts are chemically different and therefore indicated more salts or chemical compounds were released from alfalfa tissue (Table 10).

Incorporating alfalfa and vetch residues inhibited soybean plant height and leaf area, dry weight, nodule number (Tables 5, 6, 8 and 9). Alfalfa and vetch, at the 1% residue rate, inhibited stem weight more than leaf weight. The degree of inhibition was greater with the vetch residue treatment. Reduced plant height and leaf area both decrease the relative competitiveness for light of desired plants versus weeds in the field.

Table 10. Electrical conductivity and pH characterization of dried alfalfa and vetch extracts

Plant material	Electrical conductivity (1000 μ Ohmoes)	pH
Alfalfa	7.4	5.74
Vetch	4.3	6.89

The increase of corn growth with alfalfa and vetch residues may be related to stimulatory effects of allelochemicals (Tables 7 and 8). The maximum increase of corn growth occured with 0.25% and 1% of alfalfa and vetch residue, respectively. Alfalfa and vetch residue rate increased plant height, leaf area, dry weight of corn by 23%, 59%, 58% and 17%, 52%, 94%, respectively. Rice[16] suggested that stimulatory or synergistic effects would be expected when multiple allelopathic agents are present. In the case of corn, supplemental alfalfa and vetch residue had stimulatory effects on corn growth (Tables 7 and 8). This indicates that adequate legume residue may stimulate corn growth by means of nutritional contributions.

Results from these residue studies do not necessary indicate that similar results will occur in the field even though we used saucers to water the pots from the bottom up and thus prevent allelochemicals from leaching. Production and duration of allelochemicals from residue decomposition depends upon the nature of plant residue, soil type, and condition of decompisition. Plant residues could potentially release enough allelochemicals in the soil which could persist well into the growing season, thereby causing the observed effects on soybean and corn growth. It is interesting to note that alfalfa and vetch residue reduced soybean growth while stimulating corn growth. This is related to the species-specific growth regulatorty effect of allelochemicals.

In this study, aqueous extracts of alfalfa and vetch on bioassay tests of corn were poorly correlated with the results of a greenhouse study when alfalfa and vetch residues were incorporated in silica sand. The reason for the differences between aqueous extracts and residue incorporation are not known, but in both experiments the amount of residue used may result in such a difference. The release of organic and inorganic compounds is both qualitatively and quantitatively different in two experiments. Identification of allelochemicals was not attempted in this study. Research suggests that toxic substances in alfalfa may be phenolic[1,4,11,15,16,22] and that these compounds may cause allelopathy problems.

Allelochemicals can stimulate or inhibit plant growth, depending on the concentration and amount of residue. Inactivation of toxins in the soils could reduce the inhibition that occurs when residues are incorporated in silica sand. Results reported here provide potential allelopathic relationships, sensitivities of species, inhibition or stimulation effects of types and amounts of residue, and some practical application to field situations, such as crop rotation. Our observations suggest that soybean appears to be relatively sensitive and corn insensitive to allelopathic inhibition of alfalfa and vetch which in turn suggests that corn may be better suited to follow stands of alfalfa and vetch. Therefore, a farmer must consider of it would be advisable to plant soybean or corn based on the level of alfalfa or vetch residue still growing in the field.

Legume species may not be compatible with each other, as indicated by inhibition of soybean germination and growth. The presence of allelopathic substances must be further investigated. Quantification of allelopathic influences must be more thoroughly investigated in a field cropping system.

摘 要

본 실험은 alflafa 와 vetch의 추출물과 잔유물의 콩과 옥수수에 대한 타감작용을 검정하기 위해서 실시 되었다. 콩과 옥수수에 대한 타감작용을 검정하기 위해서 영양생장기 때에 수확된 alfalfa와 vetch를 건조시켜 추출물을 얻었고 또한 이들 잔기를 silica sand 와 혼합처리하여 콩과 옥수수의 생육을 검토 하였고, 콩에 대해서는 근류균의 착생정도를 조사 하였다.

1. 발아시험에서는 콩과 옥수수의 발아율, 유근의 생장, 무게 등이 추출물 농도가 증가할수록 억제 되었으며, 최고 억제정도는 추출물 농도 20%에서 발생되었다. 추출물에 대하여 콩이 옥수수보다 더 민감하게 반응하였으며, alfalfa의 추출물이 vetch의 추출물보다 더 억제적 이었다.
2. Alfalfa 와 vetch를 silica sand에 혼합하여 콩과 옥수수의 간장, 엽면적, 지상부의 생육정도를 비교하였을 때 콩의 간장, 업면적, 지상부 생육은 alfalfa처리에서 더 억제적 이었으며, 옥수수의 생육은 vetch 처리에서 촉진 되었다.
3. Alfalfa 와 vetch처리가 모두 콩 뿌리혹의 형성을 억제시켰는데 alfalfa처리가 vetch의 처리보다 뿌리혹의 형성을 더 억제 시켰다.
4. Alfalfa 와 vetch의 추출물과 잔기의 처리는 옥수수보다는 콩의 발아와 생육에 더 억제적으로 작용하므로 콩 재배의 경우에는 이들 잔기의 관리가 필요하다고 생각되어진다.

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