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Research Article

Effect of Different Herbicides on Forage Yield and Nutritive Value in Corn-soybean Mixture Cropping

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ABSTRACT

The aim of this study was to evaluate different herbicides in corn-soybean intercropping for optimum growth, yield and nutritive value of forage under Korean environment conditions. Herbicidal treatments were randomly applied over five plots, viz. (1) Control treatment: no herbicide; (2) Alachlor; (3) Simazine; (4) Pendimethalin and (5) Mixture of alachlor and simazine herbicides in RCBD have three replications. Results depicted that treated herbicides exhibited significant effect over control of weeds. Simazine herbicide alone or mixed with alachlor had adverse effects on soybean but enhanced (p<0.05) corn production in terms of survivability, dry matter and digestible nutrients yield. Corn-soybean coupling and total dry matter yield were greater (p<0.05) in pendimethalin. Simazine-alachlor mixture reduced (p<0.05) soybean height. Conclusively, simazine could not be suitable for corn soybean intercropping because of having an adverse effect on soybean component. Pendimethalin could maintain growth and yield of corn and soybean both components. Effect of alachlor was comparable to that of pendimethalin.

(**Key words** : Herbicide, Alachlor, Simazine, Pendimethalin, Corn-soybean intercropping)

Ⅰ. INTRODUCTION

In connection for the achievement of high economic growth in Republic of Korea, food consumption pattern has massively shifted towards meat and dairy products which put pressure on livestock industry to combat with increasing domestic demand. Accordingly livestock production reaches 40.2% of total Agro-forestry production (Chung et al., 2014). Consequently, national livestock population has flourished and strength of pigs, chicken, beef and dairy cattle reached to 10,355, 101,014, 2,742 and 402 thousand heads, respectively (KOSTAT, 2015). However, self sufficiency of forage production is quite low due to limited land resources and traditional cropping techniques.

Maize is preferably cultivated by Korean farmers as staple forage because it is a good source of carbohydrates and provides 60% energy and 90% starch in animals diet (Dado, 1999) but lacks protein and essential amino acids; lysine and tryptophan (Yadav, 2016). In an attempt to improve nutritive value and yield of maize forage, corn-soybean intercropping is found promising technique under limited land resources (Seo *et al*., 2014). However, farmers face weeds problem in intercropping which may create losses when not controlled. In corn, 40 to 60% production losses have been reported due to heavy weed infestation (Thobatsi, 2009). To control weeds with less labor, mostly herbicides are used for better crop yield (Santos, 2009). However, haphazard use of herbicides may have adverse effects (Judith *et al*., 2001) because different herbicides exhibit different effects on different forage species. Herbicides used for corn forage may not be adequately suitable for soybean. It is, therefore, the present the study was designed with an aim to evaluate different herbicides for optimum growth, yield and nutritive value of corn and soybean components in intercropping under Korean environment conditions.

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Ⅱ. MATERIALS AND METHODS

1. Location of research site

The study was carried out at research farm located in Cheongri, Sangju-si, Gyeongsangbuk-do, Republic of Korea from 10th June to 21st September, 2015. Geographical coordinates of research site were 36.3323° N, 128.1287° E. The comparative average temperature and total rainfall recorded during the study period and last 10 years is given in Table 1. The soil samples were taken and submitted to Central Research Laboratory, Kyungpook National University, Sangju, for analysis. The soil was sandy in nature and had following chemical properties, viz. (1) pH 7.0; (2) Electrical conductivity 0.39 ds/m; (3) Phosphate 321.8 mg/kg; (4) Nitrogen 0.2% and (5) Exchangeable cations (Ca 4.39, K 0.46, Mg 2.17, Na 0.12, cmol/kg).

2. Experimental treatments and design

An area of land having length and width (24 × 4 m) was selected and divided lengthwise into 3 blocks following randomized complete block design. Each block (7.5 × 4 m) was further divided equally into 5 plots. Each plot had length and width (1.5 × 4 m) and total 15 experimental plots were made available for random application of 5 treatments with 3 replicates. Different herbicides were used under 5 herbicidal treatments, *viz*. 1) No herbicide (control treatment); 2) Alachlor herbicide; 3) Simazine herbicide; 4) Pendimethalin herbicide and 5) Mixture of alachlor and simazine herbicides.

3. Crop husbandry

Corn seed (Variety; Pioneer-35P75) and soybean seed (Variety; crossbred P-I483463×Hutcheson) were selected for corn-soybean intercropping. The fertilizer NPK (21: 17: 17) was used at the rate of 1000 kg per hectare while preparing the land. Seeding of corn and soybean was carried out on 2 equally spaced rows in each plot as per experimental treatments. The interrow space was 0.75 meter, whereas interseed distances from soybean to soybean 10 cm and corn to corn 20 cm were fixed within a row by seeding machine named Hwangeum (HG10A model). Two border rows around the experimental area were examined to check the border effect. Herbicides were used soon after seeding. No herbicide was used after corn-soybean seeding in plots of T-1: control treatment but T-2 plots were sprayed with alachlor (brand name: Lasso, 300 ml packing) herbicide at the rate of 40 ml per 20-liter water. Likewise, simazine (brand name: Simazine, packing 200 g) herbicide was used at the rate of 33 g per 20-liter water in T-3 plots, whereas pendimethalin (brand name; Stomp, packing 300 ml) herbicide was used in T-4 plots at the rate of 60 ml per 20 liter water. Similarly, T-5 plots were sprayed with the mixture of alachlor and simazine herbicides. The response of different herbicides was observed on the survivability of plants, the emergence of weeds, growth performance, dry matter yield and nutritive value of corn-soybean intercropping forage.

4. Data collection

A number of survived plants was counted 2 weeks post seeding on 23rd June 2015 and then 3rd July 2015. The counting of following weeds was also executed on 3rd July 2015 for weed emergence, *viz.* 1) *Chenopodium album*; 2) *Digitaria sanguinalis*; 3) *Portulaca oleracea*and 4) *Echinochloa crus-galli*.

The height of maize stalk, maize ear and soybean was recorded on the day of harvesting, 21st September 2015. The maize stalk height was measured from ground to the top of plant, whereas the height of maize ear was taken from ground to the bud of ear evolved. Similarly, soybean height was measured from ground to the top of the plant. Five plants were taken randomly from each replicate for measuring data regarding the height. A

Table 1. Comparative average temperature and total rainfall in field area of Sangju, Gyeongsangbuk-do, Republic of Korea

Climate	Year	June	July	August	September
Temp (°C)	2015	22.9	25.0	25.6	20.3
	2004-2014	24.6	27.3	27.5	22
Rainfall (mm)	2015	125.2	150.7	45.0	30.9
	2004-2014	133.2	293.8	281	155.6

Source: Korea Meteorological Administration, 2015

number of stalk, ears and soybean as well as corn-soybean coupling was recorded through counting on harvesting.

5. Laboratory Analysis

Samples of corn stalk, corn ear, and soybean from each replicate were randomly taken for dry matter yield, initially weighed, dried in an oven at 70° C for 72 hours and then again weighed after drying. The kilogram of dry matter (DM) yield was also converted into tons per hectare. The percentage of DM was just calculated using fresh yield and dry matter yield information. Fiber analysis Neutral Detergent Fiber, Acid Detergent Fiber (NDF and ADF) were performed as per the procedure of Van-Soest *et al*. (1991) in the laboratory of "Forage Production and Utilization", Department of Animal Sciences, Kyungpook National University Sangju Campus, South Korea. The Relative Feed Value (RFV) and Total Digestible Nutrients (TDN) were calculated through following equations (NFTA, 2016),

RFV = Relative Feed Value = (DDM × DMI)/1.29

DDM = Digestible Dry Matter = 88.9-(0.779 × %ADF)

DMI = Dry Matter Intake (% of BW) = 120/ (%NDF)

TDN(%) = Total Digestible Nutrients = 4.898 + (89.796 × NEL)

NEL (Mcal/lb) = Net energy for lactation

= 1.0876 - (0.0127 × ADF)

6. Statistical analysis

The collected data were analyzed using ANOVA technique (Steel *et al*., 1997) through SAS 9.1.3 software. The difference among five treatment means was tested through Duncan Multiple Range Test.

III. RESULTS

1. Effect of herbicides on growth of plants

Corn stalk and ear height were not influenced (p>0.05), but soybean height was significantly lower under the mixture of alachlor and simazine than that of pendimethalin emulsion but not different from other treatments (p<0.05). However, the corn-soybean coupling is found highest numerically in pendimethalin followed by alachlor, control and simazine as elaborated in Table 2. Similarly, the effect of various herbicides was not found (p>0.05) on the number of corn stalks, corn ears and soybean in corn-soybean intercropping fields as shown in Figure 1.

2. Effect of herbicides on survivability of plants

The survival rate in corn plants was not influenced (p>0.05) depending on different herbicides as shown in Figure 2. However, simazine alone or mixture with alachlor decreased significantly (p<0.05) the survival of soybean plants, whereas other herbicides pendimethalin and alachlor did not influence (p>0.05) survivability of soybean as compared to that of control treatment (No herbicide).

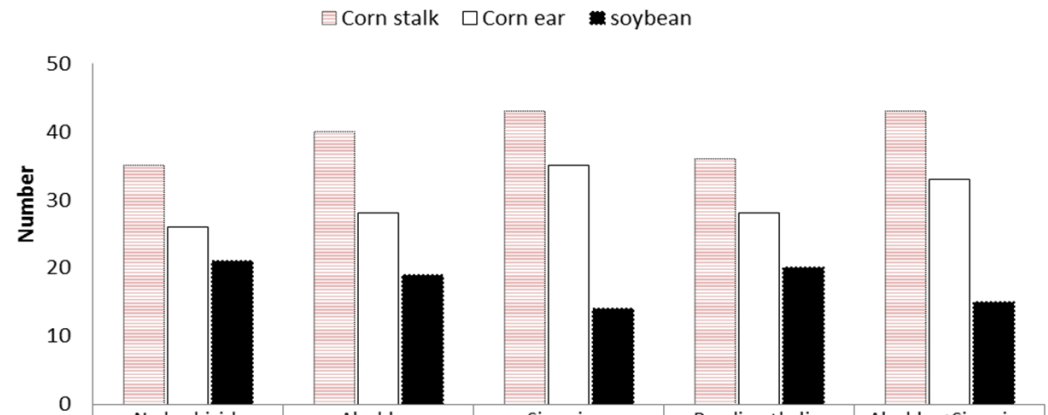
3. Effect of herbicides on forage yield

Dry matter yield in corn stalk was higher in other herbicide treatments than in control (p<0.05). Dry matter yield in corn ear was observed numerically highest in simazine, alachlor-simazine, pendimethalin, alachlor, no-herbicide (p>0.05). In the case of soybean, the pattern of dry matter yield was little reversed. It was numerically lower in treatments having simazine only or

Table 2. Effect of different herbicides on growth characteristics and coupling number of plants in corn-soybean mixed cropping forage

Growth parameters	Treatments					SEM	*P* value
	No-herbicide	Alachlor	Simazine	Pendimethalin	Alachlor+Simazine		
Corn stalk height (cm)	259	257	275	281	269	10.4	0.437
Corn ear height (cm)	112	119	131	129	130	7.6	0.367
Soybean height (cm)	50 ^{ab}	80 ^{b}	60 ^{ab}	80 ^{b}	36 ^{a}	9.4	0.019
Corn-soybean coupling (No/6m^2)	8	12	6	14	7	2.0	0.080

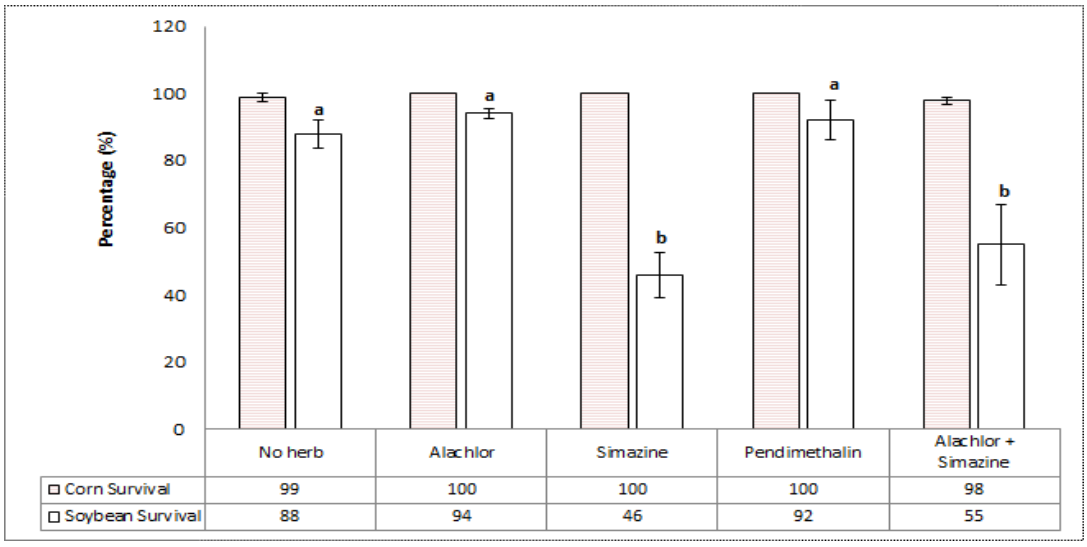
^{a,b} Variables having different superscripts in the same rows are significantly different (p<0.05) SEM: Standard error of the mean.



	No herbicide	Alachlor	Simazine	Pendimethalin	Alachlor+Simazine
Corn stalk	35	40	43	36	43
Corn ear	26	28	35	28	33
soybean	21	19	14	20	15

Fig 1. Effect of different herbicides on number of corn stalk, corn ear and soybean in corn-soybean intercropping forage.

*Same colored column-bar variables are not significantly different (p>0.05)



	No herb	Alachlor	Simazine	Pendimethalin	Alachlor + Simazine
Corn Survival	99	100	100	100	98
Soybean Survival	88	94	46	92	55

Fig 2. Effect of different herbicides on the survivability of corn and soybean plant in corn-soybean mixed forage.

[a,b] Same colored column-bar variables with different alphabets at top are significantly different (p<0.05)

with alachlor mixture. The effect of alachlor emulsion on corn and soybean was comparable (p>0.05) to that of other treatments as shown in Table 3. The percentage of soybean proportion was observed numerically highest in pendimethalin emulsion followed by alachlor, control, alachlor-simazine and simazine.

In case of NDF, different herbicidal treatments did not affect (p>0.05), whereas ADF was also found similar (p>0.05) among treatment. Similarly, RFV was also not different (p>0.05) and TDN percentage was observed similar among control, simazine, alachlor, pendimethalin and alachlor-simazine mixed herbicides, as mentioned in Table 4.

TDN yield was higher (p<0.05) in treatments having simazine only or with alachlor mixture than that of control treatment having no herbicide but it was found similar (p>0.05) with that of other herbicides.

TDN yield was increased significantly (p<0.05) in corn stalk

but decreased numerically in soybean by simazine only or with the mixture of alachlor as elaborated in Table 5. If alachlor emulsion was mixed with simazine, then total TDN yield in mixed forage could be significantly increased to higher (p<0.05) than control.

4. Effect of herbicides on emergence of weeds

A number of "*Chenopodium album*" weed was found nil in plots sprayed with simazine and pendimethalin and also reduced numerically in alachlor-simazine and alachlor than control. In the case of "*Digitaria sanguinalis*" weed, emergence was zero in pendimethalin treatment and also reduced significantly in other herbicides than that of control. In comparison to control treatment, a number of 3rd weed emergence "*Portulaca oleracea*" reduced (p<0.05) in alachlor treatment but the effect of other herbicides (simazine, pendimethalin and alachlor-simazine mixture) were better (p<0.05) than alachlor in terms of lower number of weeds. However, all herbicides were found equally more effective (p<0.05) than control against the emergence of "*Echinochloa crus-galli*" weed as mentioned in Table 6.

Table 3. Effect of different herbicides on dry matter yield in corn and soybean mixed cropping

Parameters	Treatments					SEM	P value
	No-herbicide	Alachlor	Simazine	Pendimethalin	Alachlor+Simazine		
Corn stalk (ton/ha)	4.7[a]	7.5[b]	8.0[b]	6.9[b]	7.1[b]	0.6	0.018
Corn ear (ton/ha)	4.5	4.5	7.2	5.9	6.8	0.8	0.115
Soybean (kg/ha)	446	676	257	896	318	0.2	0.116
Total (ton/ha)	9.7 [a]	12.7 [ab]	15.5 [b]	13.7 [b]	14.2 [b]	1.2	0.048
Soybean proportion (%)	5.0	5.4	1.7	6.5	2.2	1.3	0.111
Relative DM yield	100	131	159	141	147	-	-

[a,b] Variables having different superscripts in the same rows are significantly different (p<0.05), SEM: Standard error of the mean, DM: Dry Matter

Table 4. Effects of different herbicide on percent neutral detergent fiber (NDF), acid detergent fiber (ADF), relative feed value (RFV), total digestible nutrient (TDN) in corn soybean intercropping forage

Treatments	NDF (%)		ADF (%)		RFV		TDN (%)	
	Corn	Soybean	Corn	Soybean	Corn	Soybean	Corn	Soybean
Non-herbicide	54.9	47.8	30.7	31.5	150.8	173.0	66.5	65.9
Alachlor emulsion	58.3	46.5	31.7	32.2	142.0	177.6	65.8	65.4
Simazine wettable powder	58.1	44.5	32.5	31.1	142.4	185.9	65.3	66.2
Pendimethalin emulsion	57.0	47.4	32.5	31.8	145.0	174.9	65.2	65.7
Alachlor+Simazine	58.6	45.7	33.0	30.2	141.9	181.5	64.9	66.8
SEM	1.7	1.3	1.2	0.8	4.4	5.2	0.9	0.6
P values	0.6	0.4	0.7	0.5	0.6	0.5	0.7	0.5

Table 5. Effect of different herbicides on TDN yield in corn-soybean mixed cropping forage

Parameters	Treatments					SEM	*P* values
	No-herbicide	Alachlor	Simazine	Pendimethalin	Alachlor+Simazine		
Corn stalk (ton/ha)	6.1 [a]	7.9 [ab]	9.9 [b]	8.4 [ab]	9.0 [b]	0.7	0.0427
Soybean (kg/ha)	293	441	169	584	211	108.5	0.1093
Total (ton/ha)	6.4 [a]	8.3 [ab]	10.1 [b]	9.0 [b]	9.3 [b]	0.7	0.0495
Relative TDN yield	100	131	158	140	145	-	-

[a,b] Variables having different superscripts in the same rows are significantly different (p<0.05), SEM: Standard error of the mean, TDN: Total digestible nutrients

Table 6. Effect of different herbicides on weed emergence in corn-soybean mixed cropping fields

Parameters	Treatments					SEM	*P* value
	No-herbicide	Alachlor	Simazine	Pendimethalin	Alachlor+Simazine		
Chenopodium album (No/m^2)	9.2	3.7	0	0	1.8	5.0	0.1495
Digitaria sanguinalis (No/m^2)	111^{c}	27.2^{b}	42^{bc}	0^{a}	9.2^{b}	19.6	<.0001
Portulaca oleracea (No/m^2)	759^{c}	196^{b}	35^{a}	1.8^{a}	18.5^{a}	72.3	<.0001
Echinochloa crus-galli (No/m^2)	711^{b}	35^{a}	129^{a}	42.5^{a}	20.3^{a}	78.0	<.0001

^{a,b} Variables having different superscripts in the same rows are significantly different (p<0.05) SEM: Standard error of the mean

Ⅲ. DISCUSSION

1. Effect of simazine herbicide on corn and soybean

Findings of the present study depicted that simazine (herbicide of Triazine class) was found effective against the emergence of weeds because it could have an inhibitory effect on the photosynthetic activity of weeds (Chapman and Stranger, 1992). However, this herbicide supported component of corn in terms of yield, whereas it had an adverse effect on survivability and yield of soybean in corn-soybean intercropping. Enhancing yield of intercropped corn through simazine might be attributed to factors that the herbicide from Triazine class could be quite effective against broad leaf weeds without damaging corn structure because corn might have natural immunity (Ganzel, 2009) against herbicide's toxicity. The adverse effect on soybean component was also substantiated previously by Soltani *et al.* (2011) that soybean was when planted after corn cultivation and sprayed with herbicide of Triazine class, ultimately biomass yield was decreased. The possible reason for the negative effect of simazine on soybean might be attributed to the factor that it might reduce rhizobial nodulation and consequently soybean yield was decreased (Yoon *et al*., 1992). It was inferred that simazine herbicide might be suitable herbicide for monocrop corn but not for corn soybean intercropping due to having adverse effects on soybean plants.

2. Effect of pendimethalin herbicide on corn and soybean

The efficiency of pendimethalin (herbicide of dinitroaniline class) against weeds might be due to its inhibitory effect on cell division in broader leaf weeds (Roberts, 1998) and consequently improved in corn-soybean coupling and yield of corn and soybean components in the present study. Pandey and Prakash (2002) also affirmed improvement in yield of corn-soybean intercropping through pendimethalin treatment. However, as per most of the previously published articles, pendimethalin herbicide inhibits plant's cell division (Strandberg and Scott-Fordsmand, 2004) and also inhibit roots and shoots development in plant seedlings (Appleby and Valverde, 1988; Gilliam *et al*., 1993). Generally, soybean exhibit adequate resistance to pendimethalin but sometimes it may damage crop in terms of stem breakage (Glover and Schapaugh, 1997). The absence of adverse effect on soybean in the present study might be due to use low dose pendimethalin product (Stomp). However, further research is recommended. It was inferred that pendimethalin (Stomp) didn't affect growth, increase corn yield numerically than control and enhance soybean yield better than simazine.

3. Effect of alachlor herbicide on corn and soybean

Efficacy of alachlor (herbicide of chloroacetanilide) against weed emergence might be due to its ability to inhibit the onset of mitosis process in cell division of plants (Kwon and Kim, 1992). No adverse effect of alachlor on both corn and soybean components in the present study might be attributed to factor that corn and soybean were tolerant species, capable of detoxifying chloroacetanilide herbicide (alachlor) through conjugation with Glutathione and Homo-glutathione and then these conjugates could be metabolized further into inactive products (Rao, 2000). No effects of alachlor with the standard concentration on soybean growth (Yoon *et al*., 1992) and corn-soybean yields (Moorman and Dowler, 1991) were also studied previously. It was inferred that alachlor had no adverse effect on growth and enhanced corn and soybean yields numerically than control.

4. Effect of alachlor-simazine mixture on corn and soybean

Influence pattern of alachlor and simazine mixture was found similar to that of simazine herbicidal treatment. Enhancing yield in corn and lessening in soybean with reduced survivability might be attributed to a factor of simazine, which had adverse effects on soybean component of corn-soybean intercropping. So it was inferred that mixing alachlor with simazine could not be advantageous due to an adverse effect on soybean component.

Ⅳ. CONCLUSION

It concluded that simazine could not be suitable for corn soybean intercropping because of having an adverse effect on soybean component. Pendimethalin (Stomp) could maintain growth and yield of corn and soybean both components. Effect of alachlor (Lasso) on weed control was lesser than that of pendimethalin. Further research is recommended on the suitability of herbicides in corn-soybean mixed cropping.

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Ⅵ. REFERENCES

Appleby, J. R. and Valverde, B. E. 1988. Behavior of dinitroaniline herbicides in plants. Weed Science Society of America. 3:198-206.

Chapman, R. and Stranger, J. W. 1992. Horticultural pesticide residues in water: a review of potential for water contamination by pesticides used in the vegetable industry in Victoria. Research report series (Victoria. Department of Food and Agriculture), No 137. East Melbourne, Dept. of Food and Agriculture, Melbourne.

Chung SH, Lee JS, Kim MJ and Lee HG. 2014. The development status and prospect of Korean Livestock Industry. J. Animal and Vet. Advances. 13:1143-1149.

Dado, R. G. 1999. Nutritional benefits of specialty maize grain hybrids in dairy diets. Journal. of Animal. Science., 77(Suppl.2) /Journal of. Dairy Science, . 82:197-207.

Ganzel, B. 2009. Farming 1970 to today. pests_05.html. Accessed November 7, 2016.

Gilliam, C. H., Eakes, D. J. and Olive, J. W. 1993. Herbicide use during propagation affects root initiation and development. The Journal of Environmental Horticulture. 11:157-159.

Glover, D. G. and Schapaugh, W. T. 1997. Screening of soybean for pendimethalin herbicide induced stem damage. Crop Science. 37:358-360.

Herbert, S. J., Putnam, D. H. and Vargas, A. 1985. Forage production from maize soybean intercrops. Proceedings of the 15th International Grassland Congress. pp. 1266-1268.

Judith, C. S., Lemley, A. T., Hogan, S. I., Weismiller, R. A. and Hornsby, A. G. 2001. Health effects of drinking water contaminants. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida.

KOSTAT. 2015. Agriculture area survey in 2015 (According to Remote Sensing), the statistics Korea, Ministry of strategy and finance, Republic of Korea. http://kostat.go.kr/portal/eng/surveyOutline/1/1/index.static

Kwon, S. W. and Kim, J. C. 1992. A study of mode of action of *alachlor* III. Effect of *alachlor* on cell division, cell kinetics, cell elongation and cell differentiation in oat (*Avena sativa L.*). Korean Journal of Weed Science. 12:102-109.

Moorman, T. B. and Dowler, C. C. 1991. Herbicide and rotation effects on soil and rhizosphere microorganisms and crop yields. Agriculture, Ecosystems and Environment. 35: 311-325.

NFTA. 2016. Forage analysis procedures, the National Forage Testing Association. Available on line at http://www.foragetesting.org/index.php?page=lab_procedures, Accessed June, 2016.

Pandey, A. K. and Prakash, V. 2002. Weed management in maize and soybean intercropping system. Indian Journal of Weed Science. 34:58-62.

Rao, V. S. 2000. Principles of weed science. 2nd Ed. Science Publisher; Inc., NH (USA). P. 205.

Roberts, T. R. 1998. Metabolic Pathways of Agrochemicals: Herbicides and plant growth regulators. Part one. Royal Society of Chemistry. Cambridge. P. 270.

Santos, B. M. 2009. Drip-applied metam potassium and herbicides as methyl bromide alternatives for Cyperuscontrol in tomato. Crop Protection. 28:68-71.

Seo, J. D., Choe, J. H., Park, J. H., Kim, M. S., Kwon, C. H. and Lee, J. D. 2014. Yield and quality of forage produced by mixed planting

of soybean and corn. Current Research on Agriculture and Life Science. 32:105-109.

Soltani, N., Mashhadi, H. R., Mesgaran, M. B., Cowbrough, M., Tardif, F. J., Chandler, K., Nurse, R. E., Swanton, C. J. and Sikkema, P. H. 2011. The effect of residual corn herbicides on injury and yield of soybean seeded in the same season. Canadian Journal of Plant Science. 91:571-576.

Steel, R. G. R., Torrie, J. H. and Dickey, D. A. 1997. Principles and procedures of statistics. A biochemical approach 3rd. Ed. McGraw Hill Book Co. Inc. NY, USA.

Strandberg, M. and Scott-Fordsmand, J. J. 2004. Effects of Pendimethalin at lower trophic levels- a review. Ecotoxicology and Environmental Safety-Journal-Elsevier 57:190-201.

Thobatsi, T. 2009. Growth and yield responses of maize (Zea mays L.) and cowpea (Vigna unguiculatea) in a intercropping system. M. Sc. Thesis, University of Pretoria, South Africa. p. 149.

Van-Soest, P. J., Robertson, J. B. and Lewis, B. A. 1991. Methods for dietary fiber, neutral detergent fiber, and non-starch polysaccharides in relation to animal nutrition. Journal of Dairy Science. 74:3583-3597.

Yadav MR, Kumar R and Ram H. Using Quality Protein Maize as an Elite Feed and Fodder for Livestock. 2016; https://www.researchgate.net/ publication/308899920.

Yoon, C. S., Huh, S. M. and Shon, B. K. 1992. Effects of herbicides on the growth, nodulation and VA mycorrhizal infection in soybean (*Glycin max*). Korea Journal of Weed Science. 12:16-30.

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