ISSN : 1812-5379 (Print)
ISSN : 1812-5417 (Online)
http://ansijournals.com/ja

JOURNAL OF AGRONOMY

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Journal of Agronomy 7 (4): 314-320, 2008
ISSN 1812-5379

Evaluation of Different Herbicide Application Methods and Cultivation Effect on Yield and Weed Control of Corn (*Zea mays*)

[1]A.R. Niazmand, [2]M. Shaker and [3]A.R. Zakerin
[1]Department of Plant Pathology, Branch of Jahrom, Islamic Azad University, Fars, Iran
[2]Department of Agri-Machinery, Agricultural Research Center of Fars, Zarghan, Fars, Iran
[3]Department of Agronomy, Branch of Jahrom, Islamic Azad University, Fars, Iran

Abstract: To evaluate a new method of weed control in Corn (*Zea mays*) fields of Fars province of Iran and integrating in row cultivation and band spraying of Atrazine in fields of this region and their effects on yield and weed control during 2004 and 2005 crop season a new sprayer with band and broadcast spraying ability was designed and used in corn fields. Results of the first year showed band and broad cast spraying alone or combined with cultivator application in any plant heights increased yield and gave adequate weed control. In rows cultivator applications in any plant heights had not any effect on yield increasing and weed control alone. The second year results showed increasing of yield by using cultivator, but timing of cultivation had not any effect on yield. Band and broad cast spraying combined with cultivation and timing of cultivation gave similar maize yield. These results allow us to extrapolate the band application and mechanical weeding practice in the farm management of corn in Fars province.

Key words: Band sprayer, band application, broadcast application, Atrazine, post-emergence

INTRODUCTION

Corn is the most productive cereal in the world and known as the queen of cereal (Emam, 1995). In Iran, Fars is one of the important provinces of corn production with 653361.65 tons yield per year and occupied second place production among all provinces in the 2005 (FAO, 2005). In this province the usual method of weed control is post planting and broad cast application of Atrazine in the whole field.

Atrazine (2-chloro-4-ethylamino-6-isopropylamino-1, 3, 5-triazine), which is used to control annual broadleaf and grass weeds in corn (*Zea mays*), sorghum (*Sorghum* species), sugarcane (*Saccharum officinarum*) and other crops, is among the most widely used herbicides in the US (NASS, 1995).

The application method of Atrazine is pre and post planting in many world corn fields and there are two forms of application (band and broad cast) (Meister, 1992).

Vast of Atrazine has created many problems for environment and agriculture such as entering to under ground water resources and deep well or moving to far places by rain water or flooding (Babut *et al*., 1996; Adamski and Pugh, 1996; Heydel, 1998; Lowery *et al*., 1998; Kalkhoff *et al*., 2003).

Atrazine absorbed into soil particles at the absorption zone (approximately 1.5 cm under top soil). Residual Atrazine restricts what subsequent crops can be planted. In some situations, Atrazine is applied immediately after wheat harvest. This should control volunteer wheat and other weeds that germinate after wheat harvest (Thompson *et al*., 1998).

Because of these problems many researchers suggests to reduce Atrazine doses by integrating Atrazine band spraying method and cultivator (Mulder and Doll, 1993; Buhler, 1998; Clay *et al*., 1998; Donald *et al*., 2001; Swanton *et al*., 2002).

Reduced dose depends on spacing between rows and width of spraying Daniel *et al*. (1992) found that the most economic and effective control method used 15.0 cm band width plus two times hoeing, Forcella *et al*. (1992) and Teasdale (1995) found that weed control from reduced herbicide doses in corn was increased in narrow-row compared to wide-row environments.

Using cultivator between planted rows not only can control annual monocot and dicot weeds also improve better aeration and structural of some soils such as clay soils. The in-row subsoiler is a common implement used in wide-row crop production systems (76.0 cm and wider) to reduce soil compaction (Laflen *et al*., 2000). This implement loosens an area approximately 8.0 cm wide and 40.0 cm deep directly under the row. For narrow-row systems (such as wheat), bent legged subsoilers (paratill and similar implements) spaced close together to disrupt

Corresponding Author: Ali Reza Niazmand, Department of Plant Pathology, Branch of Jahrom, Islamic Azad University, P.O. Box 74135-355, Fars, Iran Tel: +98 9177104870 Fax: +98 791 3331019

most of the surface horizon are gaining wider acceptance by growers for crops grown in narrow-row culture (Laflen *et al*., 2000). Yield increases due to sub soiling are attributed to these implements disrupting the hardpan so that roots have a greater volume of soil from which to extract water (Busscher *et al*., 1995).

Minimizing environmental impact, increasing economic returns and employing non-chemical methods without sacrificing yield are the aim of integrated weed management (Buhler *et al*., 1992; Rosales-Robles *et al*., 1999). It does not mean totally replacing herbicides with other methods (Shaw, 1982). Banded application is as effective as overall when followed by timely inter-row cultivation (Mulder and Doll, 1993; Buhler, 1998; Donald *et al*., 2001; Swanton *et al*., 2002) and the amount of herbicide required can be reduced up to 84% without sacrificing crop yield (Swanton and Weise, 1991; Eadie *et al*., 1992; Sankula *et al*., 2001). In addition, banded application can reduce herbicide application costs (Manson, 1983; Parish *et al*., 1995) and environmental impact (Shock *et al*., 1998; Heydel *et al*., 1999; Prueger *et al*., 1999; Hansen *et al*., 2000; Gorneau *et al*., 2001). The purposes of this research are (i) designing a tractor band sprayer to reduce use of Atrazine dose, (ii) integrating of band spraying with cultivator to investigate their effects to control weed and yield production of corn and (iii) comparing of this new method with the common method of weed control (using broad cast application) in corn fields of Fars province.

MATERIALS AND METHODS

This research was carried out to design a new band sprayer in 2004. A new boom with an angle iron of 3 m length and 5 cm width was designed and 6 holes and 5 slits with 75 cm apart from center of each other of holes and slits was drilled into it (Fig. 1b, c). The nozzle holder was an angle iron 5×5 cm and it was supported by a piece of iron pipe and a scroll (Fig. 1c). An iron pipe with 1.25 cm radial and 40 cm length was connected to each nozzle holder and at the two end sides of each pipe a T jet nozzle (8003) and a flexible hose was placed respectively(with opening and closing valve) (Fig. 1d). By using the referred pipe nozzles could adjust vertically and horizontally. If the nozzles holder adjusts with 50 cm apart of each other, it could spray broad cast spraying on whole field and if they adjust with 75 cm apart and remaining nozzles valves are closed band spraying could apply in rows with 75 cm spacing. The vertical position of each nozzle is adjustable too.

The other parts of this device including frame, plastic tank (400 L), pump, regulator and pressure meter gauge were as same as common field sprayer (Fig. 1a-h).

The primary test of this new sprayer was done in the Agricultural Research Center of Fars. Half of the plastic tank capacity was filled up with water and by adjusting the nozzles vertically and horizontally the two methods of spraying (band and broad cast) were successfully tested.

The function of this sprayer was evaluated and compared to common tractor sprayer in order to control of weed corn. Then a corn field was selected in the Dasht Vahdat of Firoozabad in Fars province. During 2004 and 2005 crop season, corn (704 Moghan cultivar) was planted in the 3000 and 5500 square meter field area respectively by using pneumatic seed planter with rate of 25 kg ha^{-1} seeds. The rate of used fertilizers were 300 kg ha^{-1} urea, phosphate 200 kg ha^{-1}, potassium phosphate 100 kg ha^{-1} and ferric and zinc sulphate 50 kg ha^{-1}.

The experimental design was Randomized Complete Block with 3 replications. Every Block included 4 planted rows (80 m length at the first year and 100 m at second year) with 75 cm spacing between the rows for each treatment. Irrigation was provided with the interval 6 days. Atrazine (Gezaprime w.p. 80%) at 1.5 kg ha^{-1}, a post-emergence (POST) herbicide was applied with a tractor-mounted designed sprayer. Sweeps 4 rows cultivator was used in this research.

The treatments were:

- Non-spraying and non-cultivating application (control treatment)
- Cultivator application at 10 cm heights of corn plants
- Cultivator application at 25 cm heights of corn plants
- Cultivator application at 10 and 25 cm heights of corn plants
- Broad cast spraying with 50 cm apart of nozzles on boom
- Broad cast spraying with 50 cm apart of nozzles on boom and then cultivator application at 10 cm heights of corn plants
- Broad cast spraying with 50 cm apart of nozzles on boom and then cultivator application at 25 cm heights of corn plants
- Broad cast spraying with 50 cm apart of nozzles on boom and then cultivator application at 10 and 25 cm heights of corn plants
- Band spraying with 75 cm apart of nozzles on boom
- Band spraying with 75 cm apart of nozzles on boom and then cultivator application at 10 cm heights of corn plants
- Band spraying with 75 cm apart of nozzles on boom and then cultivator application at 25 cm heights of corn plants
- Band spraying with 75 cm apart of nozzles on boom and then cultivator application at 10 and 25 cm heights of corn plants

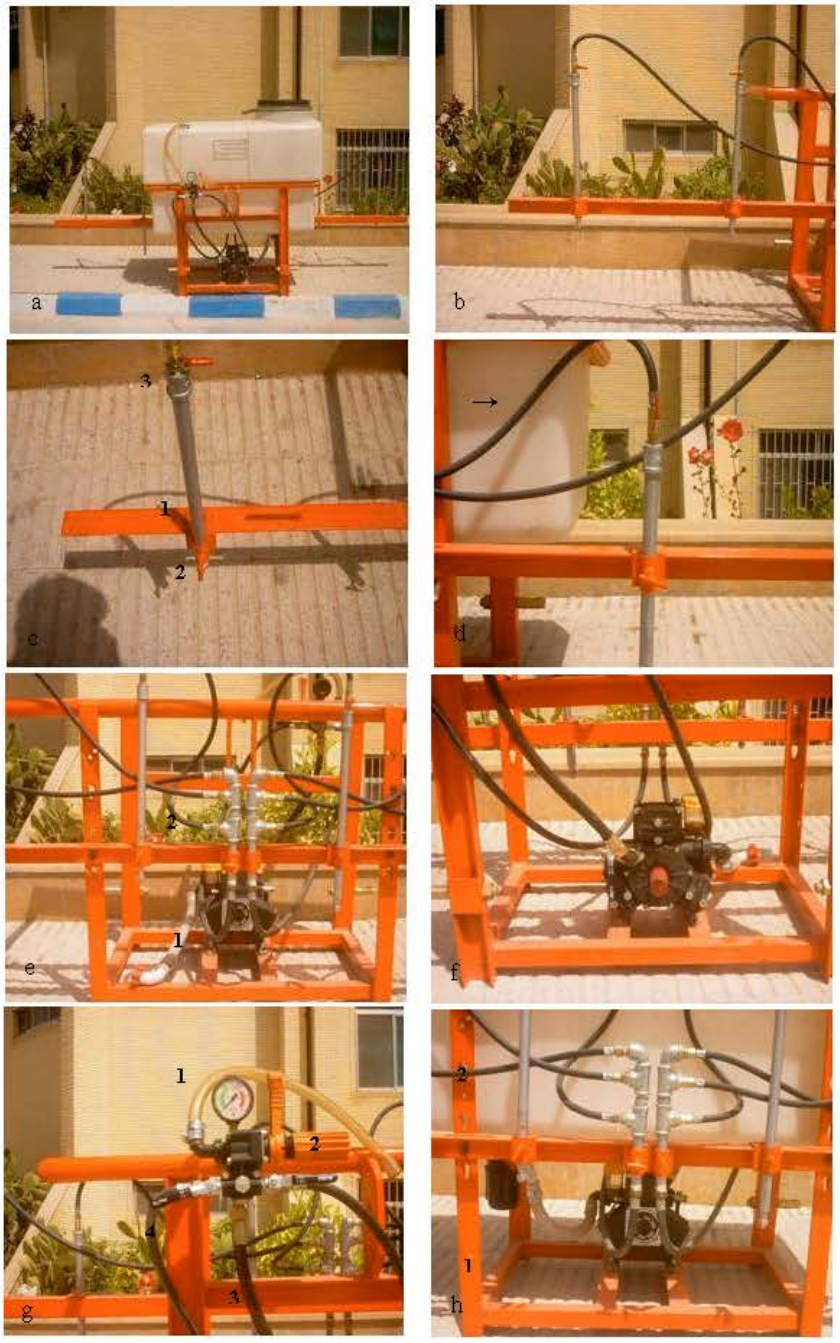

Fig. 1: Different parts of designed sprayer; (a) image of all parts of designed sprayer, (b) partial part of new designed boom, (c) angle iron with slit and hole (1), nozzle holder with scroll (2), iron pipe and valve (3), (d) flexible hose connected to valve (→), (e) image of pump (1), out coming hose and divisive hoses (2), (f) incoming and out coming hoses to pump, (g) pressure meter gauge (1), valve of pressure gauge (2), incoming hose of liquid from pump to pressure gauge (3) and two main divisive hoses to boom and their valves (4) (h). Two main hoses from pressure gauge (1) and six divided hoses to boom (2)

Table 1: Details of field applications during experiments

	Years	
Applications	2004	2005
Sowing area	3000 m^2	5500 m^2
Corn cultivar	704 Moghan	704 Moghan
Rate of used seed	25 kg ha^{-1}	25 kg ha^{-1}
Rate of used fertilizers		
Urea	300 kg ha^{-1}	300 kg ha^{-1}
Phosphate	200 kg ha^{-1}	200 kg ha^{-1}
Potassium phosphate	100 kg ha^{-1}	100 kg ha^{-1}
Zinc sulphate	50 kg ha^{-1}	50 kg ha^{-1}
Irrigation interval	6 days	6 days
Rate of used Atrazine	1.5 kg ha^{-1}	1.5 kg ha^{-1}
Cultivation timing	10, 25 cm plant heights	10,25 plant heights
Kind of cultivator	Sweeps 4 rows	Sweeps 4 rows
Nozzle spacing		
Broadcast spraying	50 cm	50 cm
Band spraying	75 cm	75 cm
Type of nozzles	T jet 8003	T jet 8003
Weed density	Pre and post spraying	------
Measuring		
Harvesting date	October	October

The identification of weed species was done before spraying and the density of weed species was recorded by using a metal quadrate (1×1 m) in each treatment. Then, the density of weed species were identified 3 weeks after exertion of each treatment as the same as previous method (metal quadrate).

Yield corn was harvested by combine in the end of October 2004 and 2005 and the seed production of each treatment was weighted. Details of field applications are in Table 1.

The results were analyzed by MSTAT-C and SAS programs and the means was analyzed with Duncan test at 5% level probability.

RESULTS AND DISCUSSION

Results of two years of plot experiments on the research fields showed *Chenopodium album, Convolvulus arvensis*, *Portulaca oleracea*, *Phalaris minor* and *Physalis* sp. were the prevalent weed species. Results of first year experiment showed that there were not any significantly differences of yield between control treatment and in row cultivator application treatments in different heights of corn (Table 2).

This result showed that in rows cultivator application had not any effect on yield increasing alone. Also from the 5 to 12th treatments were in the same statically groups and they showed significantly differences compare to control treatment but no significant differences were observed between those treatments. This means that band and broad cast spraying alone or combined with cultivator application in any plant heights could be profitable and can increase yield. Eadie *et al.* (1992) reported that band application of herbicide in conjunction with one or two cultivations gave similar weed control and maize yield compared with overall application of herbicides and a 60% reduction in total herbicide application was achieved. Donald *et al.* (2001) and Swanton *et al.* (2002) showed that band application followed by cultivation gave similar weed control, maize and soybean yield and gross return compared to broadcast application of herbicides. Mulugeta and Stoltenberg (1997) found that band application plus inter-row cultivation was as effective as broadcast applications in reducing plant population and seed bank of dominant species.

Hence, there was no significantly a difference between 9th treatment and the other treatments that used spraying combined with or without cultivator application in any plant heights could get result that the best method of spraying is band spraying. This means that it is possible to reduce herbicide application and keep yield still or increase it, this aspect is in accord with the proposal put forward by Knisel *et al.* (1995) and Donald (2007). The early results are confirmed by our work that band application with cultivator is a useful method in IWM.

The obtained results in the first year proved that there were significantly differences of weed control between control treatment and the other treatments (Table 3). It means that exertion at any treatments could effect on weed control. By analyzing the results achieved by using cultivator for weed control, it is clearly visible that there were not significantly differences between cultivator application in 10 and 25 cm plant height, but twice cultivator application could increase weed control than once cultivator application in 25 cm plant height.

Experimental results showed that band and broad cast spraying had the same effect on weed control so the band spraying is better than broad cast spraying because it reduced herbicide application quantity these results previously were reported by Bicki *et al.* (1991) too. Earlier studies had shown that a 50-84% reduction of herbicide doses was possible using band application plus inter-row tillage without scarifying weed control and crop yield (Krausz *et al.*, 1995; Donald *et al.*, 2001; Swanton and Weise, 1991; Eadie *et al.*, 1992; Sankula *et al.*, 2001; Mulder and Doll, 1993).

In the second year of experiment only yield was analyzed, because at the first year no differences were observed among treatments 5th to 12th in weed control. There were no any differences between treatments 2, 3 and 4 (Table 2). It means that cultivator application could increase yield but timing of cultivator application had not any effect on increasing yield.

Table 2: Corn yield in each experimental plots during two years experiment according to treatment No. (kg/plot)[a]

	Treatment No.											
Year	1	2	3	4	5	6	7	8	9	10	11	12
2004	120c	205.5c	197b	211bc	345a	258.5ab	253ab	260.7ab	235ab	257.5ab	252ab	257ab
2005	84e	188.0d	192d	221d	501c	590.0b	660a	666.5a	668a	670.0a	671a	6888a

[a]Means followed by the same letter do not differ (p = 0.05), according to Duncan test

Table 3: Weed control percent according to treatment No. in each experimental plots[a]

	Treatment No.											
Year	1	2	3	4	5	6	7	8	9	10	11	12
2004	0d	58bc	52.33c	64.67b	100a	100a	100a	100a	100a	100a	100a	100a

[a]Means followed by the same letter do not differ (p = 0.05), according to Duncan test

There were significantly differences in yield among treatments 5 and 6; it was obvious if cultivator application has followed band spraying the yield could increase significantly these results agree with those of Pleasant *et al.* (1994), who reported the efficiency of combining cultivation with banded herbicides to control weeds in corn.

The most productive treatments were treatments 7 to 12 which they were in the same statically groups. On the basis of these results it was obvious when cultivator combined with herbicide spraying, could increase yield rather than using these activities all alone, the same results were obtained by Heydel *et al.* (1999).

Also, there were not any significant differences between band and broad cast spraying combined with using any cultivation and timing of cultivation. Also use of cultivator combined with spraying had not any effects on increasing of yield, these results agree with Bicki *et al.* (1991), that reported corn and soybean yields, averaged over 3 years, were not significantly different for band applications with one or two cultivations or for a cultivation plus broadcast post emergence herbicide application when compared with broadcast pre emergence applications. It is also reported that cultivations with broadcast application of herbicides does not improve yield although weed control increases slightly (Mulder and Doll, 1993).

The significant differences among treatments 5 and 9 had proved two important points, at first with using two methods of spraying could get more crop production rather than cultivator application and at second by using broad cast method could result more yield than band spraying.

CONCLUSION

It is quite evident from the results in two years of experiment that climatic condition, planting and harvesting and other agricultural conditions could affect on results. In over all band spraying is more beneficial for environment and farmer economic and it would thus be sustainable. The combination of banded herbicides with mechanical weeding was as effective in controlling weeds as a broadcast application of herbicide. The banded herbicide controlled in-row weeds whereas mechanical weeding removed weeds between the rows. This integrated approach reduced herbicide use by 73% and provided adequate weed control and crop yields. Such a method is very attractive because it may give the highest economic returns. However, labor avail ability for timely mechanical weeding may still limit the effectiveness and acceptance of this practice by farmers. These results allow us to extrapolate the band application and mechanical weeding practice in the farm management of corn in Fars province.

REFERENCES

Adamski, J.C. and A.L. Pugh, 1996. Occurrence of pesticides in groundwater of the Ozark plateaus province. Water Resour. Bull., 32: 97-105.

Babut, M., P. Bombarde, C. Breuzin, C. Dory, M. Haller and F. Limaux, 1996. Recherche de pesticides dans des captages AEP en Lorraine campagne 1992. Agence de l'Eau Rhin Meuse, Metz, France. 14 pp.+annexes, 1996.

Bicki, T. J.., L. M. Wax and S.K. Sipp, 1991. Evaluation of reduced herbicide application strategies for weed control in coarse-textured soils. J. Prod. Agric., 4: 516-519.

Buhler, D.D., 1998. Effect of ridge truncation on weed populations and control in ridge tillage maize (*Zea mays*). Weed Sci., 46: 225-230.

Buhler, D.D., J.L. Gunsolus and D.F. Ralston, 1992. Integrated weed management techniques to reduce herbicide inputs in soybean. Agron. J., 84: 973-978.

Busscher, W.J., J.H. Edwards, M.J. Vepraskas and D.L. Karlen, 1995. Residual effects of slit tillage and subsoiling in a hardpan soil. Soil Tillage Res., 35: 115-123.

Clay, S.A., D.E. Clay, W.C. Koskinen and R.K. Berg Jr., 1998. Application method: Impacts on atrazine and alachlor movement, weed control, and corn yield in three tillage systems. Soil Tillage Res., 48: 215-224.

Daniel, H., C.P. Edward and J.M. Toller, 1992. Cost efficient weed control in soybean (*Glycine max*) with cultivation and banded herbicide applications. Weed Technol., 6: 990-995.

Donald, W.W., N.R. Kitchen and K.A. Sudduth, 2001. Between-row mowing + banded herbicide to control annual weeds and reduced herbicide use in no-till soybean and corn. Weed Technol., 15: 576-584.

Donald, W.W., 2007. Control of both winter annual and summer annual weeds in no-till corn with between-row mowing systems. Weed Technol., 21: 591-601.

Eadie, A.G., C.J. Swanton, J.E. Shaw and G.W. Anderson, 1992. Banded herbicide applications and cultivation in a modified no-till corn system. Weed Technol., 6: 535-542.

Emami, Y., 1995. Physiology of Tropical Crop Production. Shiraz University Publisher, Iran, pp: 305.

FAO, 2005. FAO Production Year Book. FAO, Rome, Italy, pp: 280.

Forcella, F., M.E. Westgate and D.D. Warnes, 1992. Effect of row width on herbicide and cultivation requirements in row crops. Am. J. Altern. Agric. 7: 161-167.

Gorneau, W.S., T.G. Franti, B.L. Benham and S.D. Comfort, 2001. Reducing long-term atrazine run-off from south central Nebraska. Trans. ASAE., 44: 45-52.

Hansen, N.C., S.C. Gupta and J.F. Moncrief, 2000. Herbicide banding and tillage effects on run-off, sediment and phosphorus losses. J. Environ. Qual., 29: 1555-1560.

Heydel, L., 1998. Diagnostic et maitrise des contaminations des eaux souterraines par les residus datrazine. These INPL, 3, pp: 160.

Heydel, L., M. Benoit and M. Schiavon, 1999. Reducing atrazine leaching by integrating reduced herbicide use with mechanical weeding in corn (*Zea mays*). Eur. J. Agron., 11: 217-225.

Kalkhoff, S.J., K.E. Lee, S.D. Porter, P.J. Terrio and E.M. Thurman, 2003. Herbicides and herbicide degradation products in upper Midwest agricultural streams during August base-flow conditions. J. Environ. Qual., 32: 1025-1035.

Knisel, W.G., R.A. Leonardo and F.M. Davis, 1995. Representing management practices in GLEAMS. Eur. J. Agron., 4: 499-505.

Krausz, R.F., G. Kapusta and J.L. Matthews, 1995. Evaluation of band and broadcast herbicide applications in maize and soybean. J. Prod. Agric., 8: 380-384.

Laflen M., T. Junliang and C.H. Huang, 2000. Soil Erosion and Dryland Farming. CRC Press Publication, UK., ISBN: 0849323495.

Lowery, B., R.C. Hartwig, D.E. Stoltenberg, K.J. Fermanich and K. McSweeney, 1998. Ridge tillage for corn and soybean production: Environmental quality impacts. Soil Tillage Res., 48: 145-154.

Manson, B., 1983. Cheaper weed control, is it possible? Betodlaren Sweden, 46: 49-50.

Meister, R.T., 1992. Farm Chemicals Handbook '92. Meister Publishing Company, Willoughby, Ohio.

Mulder, T.A. and J.D. Doll, 1993. Integrated reduced herbicide use with mechanical weeding in corn (*Zea mays*). Weed Technol., 7: 382-389.

Mulugeta, D. and D.E. Stoltenberg, 1997. Weed and seed bank management with integrated methods as influenced by tillage. Weed Sci., 45: 706-715.

NASS, 1995. Agricultural chemical usage-1994 field crops summary. Report Ag Ch1 (1995). USDA-NASS-ERS, Washington, DC., pp: 105. http://usda.mannlib.cornell.edu/usda/nass/AgriChemUsFC//1990s/1995/AgriChemUsFC-03-15-1995.txt.

Parish, R.L., D.B. Reynolds and S.H. Crawford, 1995. Precision-guided cultivation techniques to reduce herbicide inputs in cotton. Applied Eng. Agric., 11: 349-353.

Pleasant, J.M., R.F. Burt and J.C. Frish, 1994. Integrating mechanical and chemical weed management in corn (*Zea mays*). Weed Technol., 8: 217-223.

Prueger, J.H., J.L. Hatfield and T.J. Sauer, 1999. Field-scale Metolachlor volatization flux estimates from broadcast and banded application methods in central Iowa. J. Environ. Qual., 28: 75-81.

Rosales-Robles, E., J.M. Chandler, S.A. Senseman and E.P. Prostko, 1999. Integrated johnsongrass management in cotton with reduced rates of clethodim and cultivation. J. Cotton Sci., 3: 27-34.

Sankula, S., M.J. van Gessel, W.E. Kee, C.E. Beste and K.L. Everts Jr., 2001. Narrow row spacing does not affect lima bean yield or management of weeds and other pests. HortScience, 36: 884-888.

Shaw, W.C., 1982. Integrated weed management systems technology for pest management. Weed Sci., 30: 3-12.

Shock, C.S., M. Seddigh, J.H. Hobson, I.J. Tinsley, B.M. Shock and L.R. Durand, 1998. Reducing DCPA losses in furrow irrigation by herbicide banding and straw mulching. Agron. J., 90: 399-404.

Swanton, C.J. and S.F. Weise, 1991. Integrated weed management: The rationale and approach. Weed Technol., 5: 657-663.

Swanton, C.J., A. Shrestha, D.R. Clements, B.D. Booth and K. Chandler, 2002. Evaluation of alternative weed management systems in a modified no-tillage maize-soybean-winter wheat rotation: Weed densities. Crop Yield, Economics. Weed Sci., 50: 504-511.

Teasdale, J.R., 1995. Influence of narrow row/high population corn (*Zea mays* L.) on weed control and light transmittance. Weed Technol., 9: 113-118.

Thompson, C.R., R. Brown, D. O'Brien, J. Sartwelle and A. Schlegel, 1998. Weed control in dry land cropping systems. K-State Research and Extension, Kansas State University, MF-2339, 1998.