Indian J. Weed Sci. **41** (3 & 4) : 150-156 (2009)

Influence of Straw Management on *Phalaris minor* Retz. Control

R. S. Chhokar, Samar Singh[1], R. K. Sharma and M. Singh[2]
Resource Management Unit
Directorate of Wheat Research, Karnal-132 001 (Haryana), India

ABSTRACT

The studies were conducted to determine the effect of straw retention and burning on *Phalaris minor* control. Reduced herbicide (isoproturon and pendimethalin) efficacy and increased *P. minor* infestation were observed with rice straw burning. A survey conducted in rice-wheat system revealed that majority of the farmers (65%) were burning rice straw in north-western Indian plains. For sustainability of rice-wheat system, instead of burning, residue should be either retained on surface or incorporated. The surface retention of rice residue of 5.0 and 7.5 t/ha reduced the weed dry weight in wheat by 23.4-30.3 and 35.5-44.1%, respectively. However, the yield and weed control were lower in various residue retention treatments without herbicides as compared to the herbicide application (sulfosulfuron 25 g/ha+metsulfuron 3 g/ha). Considering advantage of residue retention, efficient weed management options need to be evolved under such residue management practices.

Key words : Isoproturon, pendimethalin, residue retention, straw burning, sulfosulfuron, tillage

INTRODUCTION

Phalaris minor Retz. (Littleseed canarygrass) is a serious economic grass weed of irrigated wheat in India. It is more problematic in Haryana and Punjab states of India, where it has evolved resistance against isoproturon (Malik and Singh, 1995; Singh *et al.*, 1999; Chhokar and Malik, 2002). It, being highly competitive, causes significant yield reductions in wheat (Malik and Singh, 1993; Afentouli and Eleftherohorinos, 1996; Chhokar and Malik, 2002).

Among various wheat based cropping systems, rice-wheat system (Malik and Singh, 1995; Singh *et al.*, 1995) provides favourable conditions for *P. minor* and as a result it is a most dominant weed of the system. In rice-wheat sequence, management of rice residue is a major problem and majority of farmers' burn rice residue particularly after combine harvesting. Straw burning is practised to speed up straw disposal for seeding wheat, especially when two rice crops are taken before wheat in a year (rice-rice-wheat). Also, loose residue interferes with the drill seeding of wheat as it draggs along the tynes. To avoid this problem, farmers practise partial or complete residue burning. Straw burning, besides affecting the germination of weeds (Wilson and Cussans, 1975; Morris, 2000), also affects the herbicide efficacy (Moss, 1979; Toth *et al.*, 1981; Embling *et al.*, 1983). Recently, two machines; rotary disc drill and turbo seeder have been developed for seeding in the presence of loose residues (Sharma *et al.*, 2008). Retention of residue on soil surface has many benefits viz., conserve moisture, moderate temperature, improve organic carbon and suppress weeds (Eguchi and Hirano, 1971; Unger, 1991; Sharma *et al.*, 2008). Tillage practices also influence weed germination and establishment (Ballard *et al.*, 1992; Chhokar *et al.*, 2007). Residue retention on soil surface in combination with a zero-till system may also significantly contribute to the suppression of weeds (Teasdale, 1998; Liebman and Mohler, 2001). Zero tillage helps to reduce weed emergence by avoiding exposure to light and through mechanical impedance to the weed seed. Stimulation of weed germination and emergence by tillage due to brief exposure to light has been observed by Ballard *et al.* (1992).

Keeping these in view, the present study was conducted to determine the effect of straw retention in suppressing weeds and also the effect of straw burning on herbicide efficacy.

MATERIALS AND METHODS

Effect of Straw Burning and Herbicides on *P. minor*

A field experiment was conducted at CCS Haryana Agricultural University, Regional Research Station, Uchani, Karnal during the 1992-93 and 1993-

[1]CCS HAU Regional Research Station, Uchani, Karnal-132 001 (Haryana), India.
[2]University of Florida, CREC, 700 Experimental Station Road, Lake Alfred, FL-33850, USA.

94 **rabi** seasons. The experiment comprised of three rice straw burning treatments (removal of straw, straw burning at 6.0 and 12.0 t/ha) and five weed control treatments (isoproturon at 1.00 and 1.25 kg/ha applied 30 days after planting wheat, pendimethalin at 1.5 kg/ha applied pre-emergence, a weedy and a weed free check). A split-plot design with four replications, with straw treatments as the main plots and weed control treatments as sub-plots, was used. The experiment was conducted in a field heavily infested with a natural population of the isoproturon resistant *P. minor* population (KNLI) after rice crop. Rice was harvested manually during last week of October removing above ground rice residues. Straw management practices were imposed 20 days before sowing (DBS) of wheat and 6 and 12 t/ha rice residue was applied on dry weight basis as per treatment. The burning of straw was immediately followed by harrowing and pre-planting irrigation. The population of *P. minor* emerged with pre-seeding irrigation was recorded just before field preparation for seeding wheat in different straw management treatments. *P. minor* density was recorded from three places in each plot during two consecutive years of study. Significance of pre-seeding *P. minor* emergence in the three straw treatments was tested using "Fisher t test" by considering two treatments at a time. For field preparation, two harrows and two cultivations with tyne cultivators were implemented to produce a fine seed bed for wheat crop. Wheat cv. HD-2285 was planted on flat beds in rows (20 cm apart) at a depth of 4 to 5 cm in plots of 5.75 m by 3.91 m. The crop was sown in the first week of December. The herbicides were applied with a knap-sack sprayer. Pendimethalin and isoproturon were sprayed immediately and 30 DAS of wheat, respectively. Weed samples were taken at 60 DAS from two randomly selected places in each plot with the help of 0.5 x 0.5 m quadrat. Angular transformation was applied to the original values of *P. minor* population for statistical analysis. Differences among treatment means were determined using ANOVA and when the F-test was significant, means were compared with LSD test at 5% level of significance.

Effect of Rice Straw Ash on Herbicide Efficacy against *P. minor* in Pots

The effect of rice straw ash on the efficacy of isoproturon and pendimethalin was evaluated against *P. minor* in pots during January 2009. For filling pots, mixture of soil and ash in the ratio (v/v) of 1 : 0 and 6 : 1 was used. *P. minor* was sown (50 seeds per pot) at a depth of 20 to 25 mm. After sowing, pots were watered. Isoproturon at 250 and 500 g/ha and pendimethalin at 500 and 1000 g/ha were applied one day after sowing with a knapsack sprayer fitted with a flat fan nozzle at 350 l/ha. The experiment was conducted in CRD having seven replications. Three weeks after herbicide spraying, per cent mortality was recorded.

Survey of Extent of Straw Burning by Farmers

A survey of 100 farmers was conducted in rice-wheat system area of Karnal, Kurukshetra and Kaithal districts of Haryana, India for the straw management practices being followed by them during 2006-07. Information was collected whether they were burning the straw of rice and wheat or not. Based on it the percentage was worked out.

Effect of Rice Residue Retention on Weeds in Wheat

A field experiment consisting of seven treatments involving five treatments under ZT (zero tillage) [Four with residue retention of 0, 2.5, 5.0 and 7.5 t/ha without herbicide and fifth treatment was residue removal with herbicide] and two treatments in CT (conventional tillage) without residues (with and without herbicides) was conducted in randomized block design. Each treatment was replicated thrice. Herbicides applied were tank mixed combination of sulfosulfuron+metsulfuron (Algrip 20 WP) 25+3 g/ha. The CT plots were prepared with rotary tiller. Immediately after rice harvesting, rice residues were uniformly spread on soil surface to achieve the desired load and at the same time residue samples were kept in oven to determine the moisture content. Finally, the additional quantity of residue was added based on moisture content. Thereafter, the seeding of wheat cultivar PBW 343 was done using seed rate of 100 kg/ha with rotary disc drill on 20 November, 2006 and 8 November, 2007. Thirty-five days after sowing, spraying of tank mixture of sulfosulfuron 25 g+metsulfuron 3 g/ha was done in herbicide treatments using a knapsack sprayer fitted with flat fan nozzles. The weed dry weight was recorded 120 DAS. The crop was harvested manually and yield was recorded at 12% moisture. Differences among treatment means were determined using ANOVA and when the F-test

was significant, means were compared with LSD test at 5% level of significance.

RESULTS AND DISCUSSION

Effect of Rice Straw Burning and Herbicides

To determine the effect of straw burning on emergence of *P. minor,* tillage and pre-seeding irrigation were given after imposing straw burning treatments (straw removal and straw burning 6 and 12 t/ha). *P. minor* population was significantly higher in plots with burnt straw than straw removed. The population further increased significantly with the increase in the quantity of straw burnt from 6.0 to 12.0 t/ha (Fig. 1). The average *P. minor* population in straw removal, straw burning 6 and 12 t/ha treatments was 311, 408 and 568 plants/m^2, respectively.

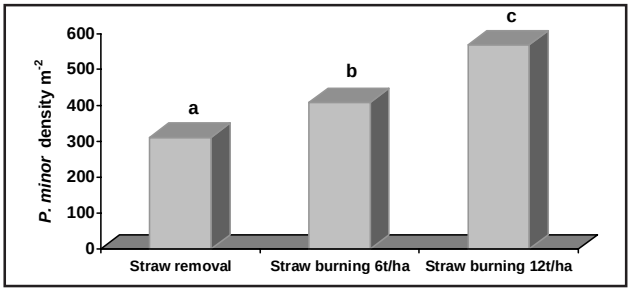

Fig.1. Effect of straw burning on *P. minor* germination after pre-seeding irrigation. Data followed by different letters differ significantly at 5% level of significance using two treatments at a time in "t test".

Increased *P. minor* population due to straw burning may be attributable to seed germination being stimulated by higher temperature or smoke during burning. As the soil remained moist and the weather remained cool and humid, straw burning did not raise the soil temperature to an extent to hamper the seed viability. Improvement in seed germination with smoke was reported by Roche *et al.* (1994), Dixon *et al.* (1995), Drewes *et al.* (1995) and Thomas and Van Staden (1995). Smoke and heat treatments combined led to the highest and quicker germination response in four species of East Australian *Grevillea* species (Morris, 2000). Edwards and Whelan (1995) also observed slight germination increase in *G. macleayana* after subjecting the seed to short heat exposure and to scarification. They postulated that *Grevilla* seeds were dormant due to a hard seed coat and were only broken by scarification or cracks caused by heat exposure.

The effect of residue burning on weed seeds depends on the quantity of residue, conditions at the time of burning and location of seeds in the soil. Puddling and tillage in rice make the distribution of *P. minor* seeds in the upper 15 cm soil layer (Chhokar *et al.*, 2007). After rice harvest, high humidity, high soil moisture and low ambient temperature at the time of wheat sowing (mean temperature of about 20-25ºC) make straw-burning favourable for *P. minor* germination. However, if wheat residues are burnt then weed population can be drastically reduced due to more heat effect caused by prevailing hot and dry weather (mean temperature around 40ºC at wheat maturity) as well as the presence of weed seeds on the soil surface after shedding. It has been reported that straw burning can increase the surface temperature to 55°C (Cook, 1939), which is likely to destroy seeds on the soil surface. Soil temperature due to burning decreases at a rate of 10°C/cm in the first 5 cm below the soil surface (Sanchez, 1976).

There was a statistical significant interaction between straw burning and herbicides for *P. minor* population (Fig. 2). The straw burning besides improving the germination of *P. minor* also affected the herbicide efficacy. *P. minor* density in 12 t/ha straw burning was significantly higher than 6 t/ha and straw removal under three herbicide treatments**.** Whereas under untreated control, both straw burning treatments were statistically similar but these had significantly higher *P. minor* over straw removal treatment. Wilson and Cussans (1975) reported similar findings on winter wild oat (*Avena ludoviciana* Dur.). Isoproturon and pendimethalin significantly reduced the population of *P. minor* compared to weedy plots. Isoproturon 1.25 kg/ha and pendimethalin at 1.5 kg/ha were equivalent with regard to efficacy. In plots with straw removal and straw burned at 6.0 t/ha isoproturon 1.25 kg/ha provided significantly better weed control than in plots where 12.0 t/ha of straw was burnt. Reduction in weed population due to herbicides was 79-86%, where straw was removed but burning of straw @ 12.0 t/ha caused a reduction of 58-65% compared to weedy check. This has been further confirmed in pot experimentation (Fig 3.), where the soil mixed with ash resulted in reduced efficacy of isoproturon and pendimethalin. The per cent mortality with and without ash for isoproturon 500 g/ha and pendimethalin 1000 g/ha was 30.4 and 79.7 and 6.9 and 99.4%, respectively (Fig. 3).

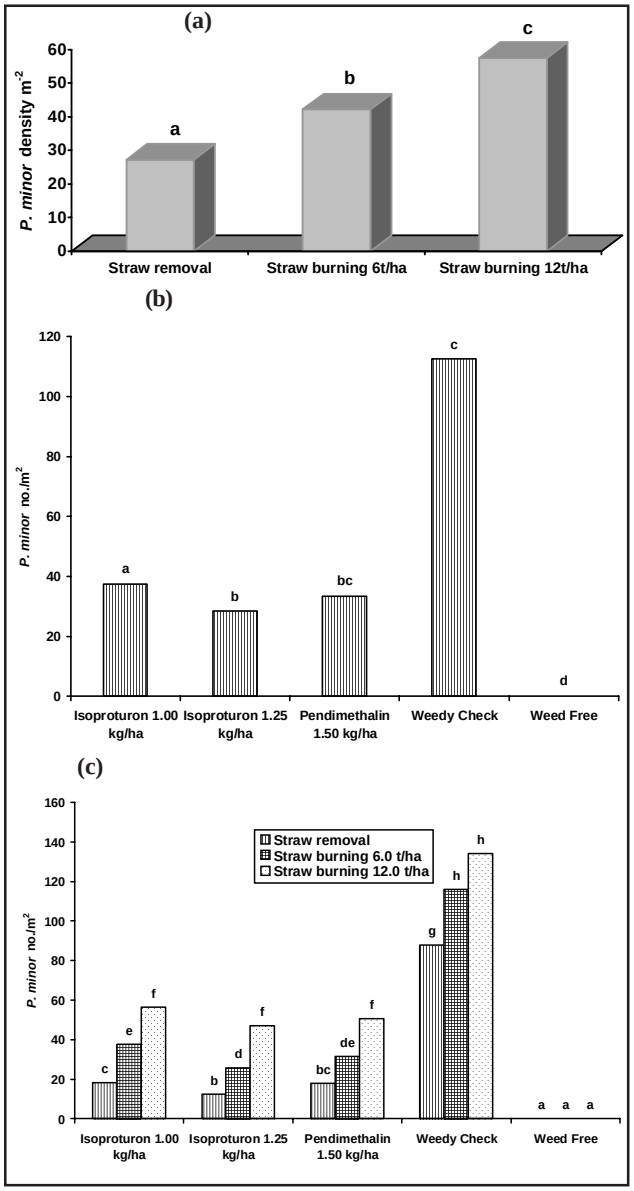

Fig. 2. Effect of (a) rice straw burning, (b) two herbicides and (c) interaction of straw burning and herbicide on population of *P. minor* at 60 DAS. Data followed by same letters do not differ significantly at 5% level of significance.

This suggests that the reduced efficiency of herbicides with burning of straw might be due to adsorption to ash particles. Previous work also established that increased adsorption of herbicides on carbon content of ash could be responsible for decreased efficiency of chlorotoluron, isoproturon, atrazine, thiobencarb and molinate (Moss, 1979; Toth *et al.*, 1981; Embling *et al.*, 1983).

The survey conducted in the rice-wheat

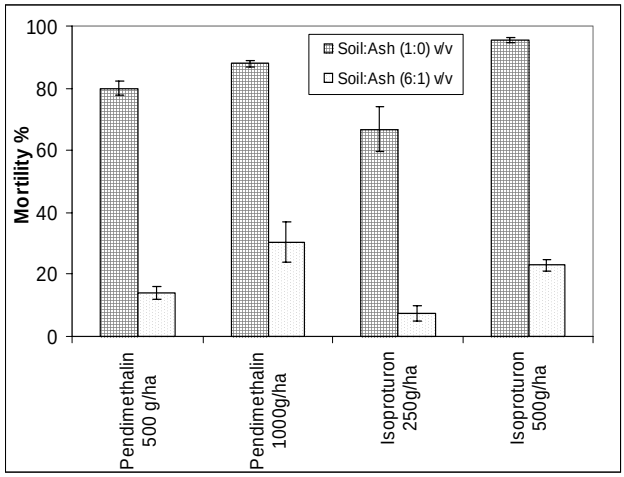

Fig. 3. Effect of paddy straw ash on herbicide efficacy against *P. minor* in pot study. The vertical bars represent the SEm.

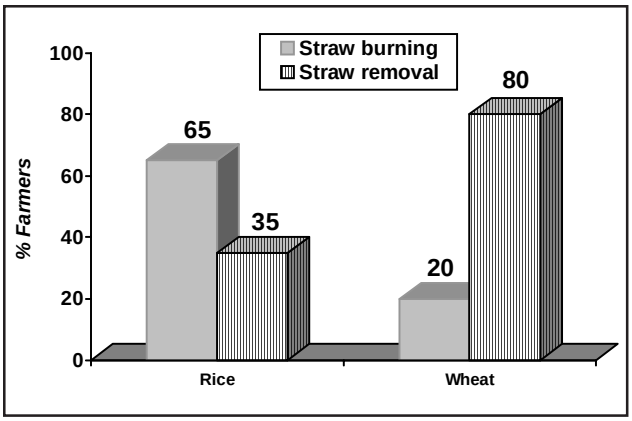

Fig. 4. Adoption of straw burning in rice and wheat crop.

cropping system of Haryana state revealed that majority of the farmers (65%) burnt rice straw to speed up field preparation by rapid straw disposal (Fig. 4). About 35% farmers practised removal and incorporation of rice straw. In case of wheat, 80% farmers removed straw for fodder and 20% either burnt or incorporated.

Rice straw burning besides improving the germination of *P. minor* also reduces the isoproturon efficacy (Figs. 1, 2 and 3) and might have contributed to the evolution of isoproturon resistance through increased selection pressure. It has been hypothesised that isoproturon resistance appeared mainly due to frequent and under-dose usage of isoproturon. The other problems associated with straw-burning on a long term basis are deterioration of soil health and environmental pollution (Sharma *et al.*, 2008).

Effect of Residue Retention on Weeds in Rice-wheat System

The retention of 5.0 and 7.5 t/ha rice residue significantly reduced weeds compared to residue of 2.5 t/ha and complete removal (Tables 1 and 2). The reduction in weed dry weight with residue retention of 5.0 and 7.5 t/ha was 23.4-30.3 and 35.5-44.1%, respectively, compared to residue removal. The weed flora in ZT and CT were dominated by broad-leaved (*Rumex* spp. and *Medicago denticulata*) and grassy (*P. minor*) weeds, respectively. Earlier research work also supports this finding of higher broad-leaved weeds in ZT and higher *P. minor* in CT (Chhokar *et al.*, 2007).

The minimum weed dry weight was in herbicide treatment involving tank mix application of sulfosulfuron+metsulfuron at 25+3 g/ha. The broad-spectrum weed control with the combination of sulfosulfuron+metsulfuron has also been reported earlier by Chhokar *et al.* (2007). Without herbicide application, residue retention of 5.0 and 7.5 t/ha provided better wheat grain yield over 0 and 2.5 t/ha residue load. However, the yields and weed control were lower in various residue retention treatments without herbicide compared to herbicide application. Also, with herbicide, no significant yield difference in ZT and CT treatment was observed. Though these two tillage systems differed without herbicide application and CT yielded significantly better compared to ZT wheat. This was mainly due to more broad-leaved weeds in ZT system.

Zero-till wheat under rice-wheat system reduces the *P. minor* emergence due to increased soil strength (Chhokar *et al.*, 2002; Chhokar *et al.*, 2007). In ZT wheat, non-selective herbicides like glyphosate and paraquat can be mixed with pre-emergence herbicide like pendimethalin or trifluralin for the control of emerged and subsequent emerging weeds. The subsequent flush will be considerably reduced due to lesser soil disturbance. Trifluralin provides selective weed control in wheat (Rahman and Ashford, 1972; Malik *et al.*, 1995)

Table 1. Effect of residue retention and herbicide on weeds in wheat under rice-wheat system during 2006-07

Treatments	Weed dry weight (g/m^2)						Wheat yield (t/ha)
	P. minor	*Medicago denticulata*	*Rumex dentatus*	*Polypogon monsplensis*	Others	Total	
ZT+residue removal (RR)	184.7	221.0	140.3	78.5	47.7	672.3	1.58
ZT+2.5 t/ha residue	182.7	229.3	145.0	70.4	55.0	682.4	1.72
ZT+5.0 t/ha residue	125.0	172.6	116.0	58.0	43.3	514.9	2.31
ZT+7.5 t/ha residue	99.7	163.0	91.7	47.3	31.7	433.3	2.12
ZT (RR) with sulfosulfuron+metsulfuron at 25+3 g/ha	13.5	0.0	1.4	4.0	0.9	19.8	4.54
CT without herbicide and residue	241.0	162.3	19.0	3.0	37.5	462.9	1.86
CT with sulfosulfuron+metsulfuron at 25+3 g/ha	3.9	0.3	0.0	1.0	0.4	5.6	4.70
LSD (P=0.05)	66.2	54.9	25.2	16.1	15.69	83.5	0.56

Table 2. Effect of residue retention and herbicide on weeds in wheat under rice-wheat system during 2007-08

Treatments	Weed dry weight (g/m^2)				Wheat yield (t/ha)
	P. minor	*Medicago denticulata*	*Rumex dentatus*	Total	
ZT+residue removal (RR)	291.0	215.1	297.3	803.4	0.75
ZT+2.5 t/ha residue	304.6	175.4	310.1	790.0	1.05
ZT+5.0 t/ha residue	214.8	130.1	214.6	559.6	2.58
Z+7.5 t/ha residue	190.9	123.4	134.6	449.0	2.46
ZT (RR) with sulfosulfuron+metsulfuron at 25+3 g/ha	2.9	0.0	0.0	2.9	5.48
CT without herbicide and residue	466.7	44.6	7.5	518.9	1.22
CT with sulfosulfuron+metsulfuron at 25+3 g/ha	0.3	0.0	0.0	0.3	5.61
LSD (P=0.05)	83.5	52.5	67.4	122.2	0.39

but its adverse effect on germination of wheat (Malik *et al*., 1995), needs to be addressed by adjusting the application timing or by increasing seed rate. Further, ZT with residue retention will be more beneficial. The retention of residue on the surface is more beneficial than incorporation and burning, as it helps in moisture conservation and weed control through mulching (Crutchfield *et al.*, 1986; Wicks *et al.*, 1994). Recently, the development of machines, Rotary disc drill and Turbo seeder has made the seeding under loose residue feasible (Sharma *et al.*, 2008). Therefore, residue retention can be effectively implemented. Future studies need to be conducted on the long term effect of residue retention on wheat production, weed dynamics and herbicide performance.

REFERENCES

Afentouli, C. G. and I. G. Eleftherohorinos, 1996. Littleseed canary grass (*Phalaris minor*) and short spiked canary grass (*Phalaris brachystachys*) interference in wheat and barley. *Weed Sci.* **44** : 560-565.

Ballard, C. L., A. L. Scopel, R. A. Sánchez and S. R. Radosevich, 1992. Photomorphogenic processes in the agricultural environment. *Photochem. and Photobiol.* **56** : 777-788.

Chhokar, R. S. and R. K. Malik, 2002. Isoproturon resistant *Phalaris minor* and its response to alternate herbicides. *Weed Technol.* **16** : 116-123.

Chhokar, R. S., R. K. Sharma, G. R. Jat, A. K. Pundir and M. K. Gathala, 2007. Effect of tillage and herbicides on weeds and productivity of wheat under rice-wheat growing system. *Crop Prot.* **26** : 1689-1696.

Cook, L. 1939. A contribution to our information on grass burning. *S. Afr. J. Sci.* **36** : 270-282.

Crutchfield, D. A., G. A. Wicks and O. C. Burnside, 1986. Effect of winter wheat (*Triticum aestivum*) straw mulch level on weed control. *Weed Sci.* **34** : 110-114.

Dixon, K. W., S. Roche and J. S. Pate, 1995. The promotive effect of smoke derived from burnt native vegetation on seed germination of a western Australian plant. *Oecologia* **101** : 185-192.

Drewes, F. E., M. T. Smith and J. Van Staden, 1995. The effect of a plant derived smoke extract on the germination of light sensitive lettuce seed. *Plant Growth Regulation* **16** : 205-209.

Edwards, W. and R. Whelan, 1995. The size, distribution and germination requirements of the soil stored seed bank of *Grevillea barklyana* (Proteaceae). *Aust. J. Ecol.* **20** : 548-555.

Eguchi, H. and J. Hirano, 1971. Effect of combinations of tillage and non-tillage, straw mulching and fertilization on weed communities in rice-wheat cropping. *Weed Res., Japan* **12** : 36-39.

Embling, S. J., E. G. Cotterill and R. J. Hance, 1983. Effect of heat treating soil and straw on the subsequent adsorption of chlortoluron and atrazine. *Weed Res.* **23** : 357-363.

Liebman, M. and C. L. Mohler, 2001. Weeds and the soil environment. pp. 210-268. In : *Ecological Management of Agricultural Weeds*, M. Liebman *et al*. (eds.). Cambridge University Press, New York.

Malik, R. K., A. Yadav, V. K. Garg, R. S. Balyan, Y. S. Malik, R. S. Malik, S. Singh and Rupa Dhawan, 1995. Herbicide resistance, current status and research findings. *Ext. Bull.* Haryana Agril. Univ., Hisar, India. pp. 5.

Malik, R. K. and S. Singh, 1993. Evolving strategies for herbicide use in wheat : Resistance and integrated weed management. In : Proc. Int. Symp. Integrated Weed Manage. for Sust. Agril. Ind. Soc. Weed Sci., 18-20 Nov., Hisar, India, **Vol. 1** : 225-238.

Malik, R. K. and S. Singh, 1995. Littleseed canary grass (*Phalaris minor* Retz.) resistance to isoproturon in India. *Weed Technol.* **9** : 419-425.

Morris, E. C. 2000. Germination response of seven east Australian *Grevillea* species (Proteaceae) to smoke, heat exposure and scarification. *Aust. J. Bot.* **48** : 179-189.

Moss, S. R. 1979. The influence of tillage and method of straw disposal on the survival and growth of black grass (*Alopecuras myosuroides)* and its control by chlortoluron and isoproturon. *Ann. Appl. Biol.* **91** : 91-100.

Rahman, A. and R. Ashford, 1972. Control of green foxtail in wheat with trifluralin. *Weed Sci.* **20** : 23-27.

Roche, S., K. Dixon and J. Pate, 1994. Smoke–a new process for germinating Australian plants. *Aust. Hort.* **91** : 46-48.

Sanchez, P. A., 1976. Soil management in shifting cultivation areas. pp. 346-412. In : *Properties and Management of Soils in the Tropics*. John Wiley and Sons, Raleigh, North Carolina.

Sharma, R. K., R. S. Chhokar, M. L. Jat, S. Singh, B. Mishra and R. K. Gupta, 2008. Direct drilling of wheat into rice residues : Experiences in Haryana and western Uttar Pradesh. In : *Permanent Beds and Rice-residue Management for Rice-wheat Systems in the Indo-Gangetic Plain*, Humphreys, E. and Roth, C. H. (eds.). Proc. Workshop held in Ludhiana, India, 7-9 Sept., 2006. ACIAR Proc. No. **127** : 147-158.

Singh, S., R. C. Kirkwood and G. Marshall, 1999. Biology and control of *Phalaris minor* Retz. (littleseed canary grass) in wheat. *Crop Prot.* **18** : 1-16.

Singh, S., R. K. Malik, R. S. Balyan and S. Singh, 1995.

Distribution of weed flora of wheat in Haryana. *Ind. J. Weed Sci.* **27** : 114-121.

Teasdale, J. R. 1998. Cover crops, smother plants, and weed management. pp. 247-270. In : *Integrated Weed and Soil Management*, J. L. Hatfield *et al.* (eds.). Ann Arbor Press, Chelsea, MI, USA.

Thomas, T. and J. Van Staden, 1995. Dormancy break of celery (*Apium graveolens* L.) seeds by plant derived smoke extract. *Pl. Growth Regulation* **17** : 195-196.

Toth, J., P. J. Milham and J. M. Raison, 1981. Ash from rice stubble inactivates thiobencarb and molinate. *Weed Res.* **21** : 113-117.

Unger, P. W. 1991. Organic matter, nutrient and pH distribution in no- and conventional-tillage semi-arid soils. *Agron. J.* **83** : 186-189.

Wicks, G. A., D. A. Crutchfield and O. C. Burnside, 1994. Influence of wheat (*Triticum aestivum*) straw mulch and metolachlor on corn (*Zea mays*) growth and yield. *Weed Sci.* **42** : 141-147.

Wilson, B. J. and G. W. Cussans, 1975. A study of population dynamics of *Avena fatua* L. as influenced by straw burning, seed shedding and cultivations. *Weed Res.***15** : 249-258.