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Effects of Wheat Straw and Farmyard Manure Mulches on Overcoming Crust Effect, Improving Emergence, Growth and Yield of Soybean and Reducing Dry Matter of Weeds

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Abstract: Poor plant stand is one of the important factors responsible for low yields of soybean (*Glycine max* (L.) Merrill). Poor plant stand, apart from other reasons, could also be due to rainfall soon after sowing but before emergence of the crop, which results in crust formation. The aim of the present study was to improve the emergence of soybean under crusted field conditions. Two field experiments were conducted on a loamy sand soil during kharif (rainy) season of 1999 and 2001 to study the effects of various mulching treatments on the emergence of soybean under simulated and natural rainfall. Under simulated rainfall the emergence of soybean was not only quicker but was also improved by covering rows with the use of 3 t wheat straw ha^{-1} and 5 t farmyard manure (FYM) ha^{-1} over no use of mulch (28.5, 26.5 and 18.5 plants m^{-1} row length after 6 days of sowing, respectively). Under natural rainfall the emergence improved substantially with the use of wheat straw mulch when only the rows of soybean were covered with it using 3 t straw mulch ha^{-1} (row mulch) or the whole plot was covered using 6 t straw mulch ha^{-1} (plot mulch). Row mulch, plot mulch and non-mulched plots had 23.0, 25.3 and 8.6-9.8 plants m^{-1} row length, respectively after 12 days of sowing. Row mulch as well as plot mulch treatments were very effective in reducing dry matter of weeds.

Key words: Crust formation, emergence, farmyard manure, mulch, wheat straw

INTRODUCTION

Soybean (*Glycine max* (L.) Merrill) is an important oilseed crop in the world. In India, the sowing of soybean is done during June and July; the sowing period coincides with monsoon rain. Rainfall after sowing but before emergence of the crop plants results in crust formation, leading to poor emergence and consequently low plant stand and grain yields.

Raindrop impact causes physical compaction of the soil surface and eventually the formation of a crust. Large drops produce crusts of sufficient strength to possibly affect seedling emergence. Soil strength due to crust is higher in soils having high clay content and under high amount of rainfall (Lee *et al.*, 1996). Soil crusting by simulated rain decreased seedling emergence of barley and oilseed rape from 76 to 40% and 82 to 61%, respectively (Shiel and Yuriwo, 1993). Seedling emergence of rice (Lee *et al.*, 1996) and cotton (Nabi *et al.*, 2001) was also decreased following soil crust formation due to simulated rainfall.

Patchy plant stand is a major factor for low yields of soybean. To obtain high yields there is a need to improve plant stand through higher emergence. Effects of straw mulches (Singh and Kler, 1990; Singh and Jolly, 2008) and shredded newspaper mulch (Munn, 1992) have been tested on the emergence of soybean. The straw mulch maintains good conditions for emergence of soybean. Straw mulches lower the maximum soil temperature (Singh and Kler, 1990), raise the minimum soil temperature (Kitoh and Yoshida, 1996) in the seed zone and keep the soil moist (Munn, 1992) and thus enhance the rate and final count of seedling emergence (Singh and Jolly, 2008). Apart from straw mulches, mulching with farmyard manure may also improve emergence in some crops (Chaudhri and Das, 1980; Singh and Jolly, 2008).

In India, sowing of soybean is done in June-July (AICRPS, 2004). The sowing period coincides with monsoon rains, which, if occur, result in crust formation, causing poor emergence and consequently low yields. Thus, there was a dire need to test the potential of straw mulch as well as FYM mulch on overcoming crust effects and improving emergence of soybean. As straw mulch is expected to suppress weeds, therefore, its effect on weeds was also tested. Two field experiments were conducted with these objectives and the results of this study are reported in this study.

MATERIALS AND METHODS

Site Characteristics

Two field experiments were conducted during kharif (rainy) season of 1999 and 2001 at the Punjab Agricultural University, Ludhiana, India on a loamy sand soil. Rainfall and temperature data recorded at the Meteorological Observatory of the Punjab Agricultural University, Ludhiana during June-August of the year 1999 to 2003 are given in Table 1. As stated above, 1999 and 2001 were the experimental years and data from 1999 to 2003 are presented to show the rains generally received and temperature experienced during the probable sowing period in Northern India.

Table 1: Rainfall and temperature during June-August from 1999 to 2003

			Temperature (°C)	
Year/Month	No. of rainy days	Total rainfall (mm)	Min	Max
1999				
June	3	24.4	24.6	36.9
July	10	359.2	26.7	33.9
August	5	68.6	25.5	33.8
2000				
June	4	88.2	27.1	36.1
July	7	189.4	26.8	33.2
August	10	120.8	26	34.1
2001				
June	7	221	30.5	35.3
July	9	383.8	29.9	33.3
August	4	312.5	30.3	35.3
2002				
June	4	36.7	27.2	37.8
July	3	36.8	28.1	36.6
August	3	24.5	27.2	34.9
2003				
June	5	49.6	27.5	39
July	13	180.6	26.3	33.5
August	9	297.7	26.6	33.5

Experiment 1

Effect of simulated rain on emergence of soybean was studied in four treatments, viz., wheat straw mulch at 3 t ha^{-1} applied on rows only, FYM mulch at 5 t ha^{-1} applied on rows only, crust breaking 3 days after sowing (2 days after simulated rain) and control without any mulch or crust breaking. The experiment was conducted in a randomized complete block design having four replications. Soybean cv., SL 295 was sown on 16 June 1999 in rows 45 cm apart using 85 kg seed rate ha^{-1}. Immediately after sowing mulching with wheat straw and FYM, as per the treatments, was done by covering only the rows of soybean. One day after sowing 1 cm simulated rain was made using a knapsack sprayer fitted with low pressure/high flow rate deflector nozzle. In case of crust breaking treatment, crust was broken by using a rake. Data on emergence count were recorded 3, 4, 5 and 6 Days After Sowing (DAS) from two fixed spots of one meter row length each and average worked out.

Experiment 2

Eight treatments, as given in Table 2-4, were tested in a randomized complete block design having four replications. For row mulch and plot mulch treatments, wheat straw at the rate of 3 and 6 t ha^{-1}, respectively, was used to cover the rows only (row mulch) or the whole

Table 2: Effect of wheat straw mulch and weed control treatments on emergence count of soybean (rainfall occurred after a few hours of sowing)

	No. of plants m^{-1} row length				
	Days after sowing				
Treatments	3	5	7	10	12
Pendimethalin 0.45 kg ha^{-1}	1.6	7.1	8.8	12.6	12.6
Pendimethalin 0.45 kg ha^{-1}+ Row mulch	2	16.1	19.5	19.5	21.3
Pendimethalin 0.45 kg ha^{-1}+Plot mulch	3.8	15.5	18.0	18.5	18.6
Pendimethalin 0.45 kg ha^{-1}+HW 30 DAS	0.2	3.1	5.0	8.3	8.3
Row mulch	2.8	20.0	24.0	24.0	25.3
Plot mulch	3.8	19.3	21.6	22.3	23.0
2 HW 30+45 DAS	1.5	6.1	8.1	9.5	9.8
Weedy control	1	4.0	5.1	8.6	8.6
CD (p = 0.05)	1	4.1	4.8	5.3	5.1

Table 3: Weed dry weight and weed control efficiency as influenced by wheat straw mulch and weed control treatments

Treatments	Weed dry weight (kg ha^{-1})	Weed control efficiency (%)
Pendimethalin 0.45 kg ha^{-1}	3459	13.84
Pendimethalin 0.45 kg ha^{-1}+Row mulch	1662	58.60
Pendimethalin 0.45 kg ha^{-1}+Plot mulch	1102	72.55
Pendimethalin 0.45 kg ha^{-1}+HW 30 DAS	2154	46.35
Row mulch	3375	15.94
Plot mulch	2609	35.01
2 HW 30+45 DAS	1015	74.71
Weedy control	4015	-
CD (p = 0.05)	679	-

Table 4: Effect of wheat straw mulch and weed control treatments on plant characters and grain yield of soybean

Treatments	Plant height (cm)	Pods $plant^{-1}$	Grain yield (kg ha^{-1})
Pendimethalin 0.45 kg ha^{-1}	72.4	32.0	353
Pendimethalin 0.45 kg ha^{-1}+Row mulch	76.4	34.7	816
Pendimethalin 0.45 kg ha^{-1}+Plot mulch	83.1	41.2	1136
Pendimethalin 0.45 kg ha^{-1}+HW 30 DAS	73.2	34.5	673
Row mulch	78.2	35.0	471
Plot mulch	73.7	35.6	698
2 HW 30+45 DAS	69.6	40.0	656
Weedy control	66.2	33.5	235
CD (p = 0.05)	6.1	5.4	432

plots (plot mulch) immediately after sowing, which was done on 15 June 2001. Cv SL 295 was sown in rows 45 cm apart using 85 kg seed rate ha^{-1}. The herbicide pendimethalin was applied, as per treatments, immediately after sowing using a knapsack sprayer using 500 L of water ha^{-1}. Luckily, a few hours after sowing rainfall occurred, thus the objective with which the experiment was planned was fulfilled, otherwise crust had to be formed by simulated rain, i.e., by sprinkling/spraying lot of water. Weeds were allowed to grow except in two treatments (pendimethalin 0.45 kg ha^{-1}+Hand Weeding (HW) and 2 HW) where weeds were controlled by hand weeding 30 and 30+45 DAS, respectively, so that the effects of mulching on weeds could be examined.

Data on emergence count were recorded 3, 5, 7, 10 and 12 DAS by counting the number of seedlings per meter row length at two spots from each plot and then averaged. Data on dry weight of weeds were recorded at harvest. The most predominant weed species was *Commelina benghalensis*; though a few plants of *Cyperus rotundus*, *Dactyloctenum aegyptiacum* and *Eragrostis pilosa* were also present.

RESULTS AND DISCUSSION

Effects on Emergence Count

Covering of soybean rows with wheat straw as well as FYM mulches showed a profound effect on improving the emergence of soybean (Fig. 1) under simulated rain. In these treatments emergence was not only higher but quicker also, as compared to the other two treatments. Row mulch as well as plot mulch treatments were very effective in improving the emergence of soybean when the crop received rainfall before emergence (Table 2). Furthermore, mulch treatments (both row mulch and plot mulch) had much faster emergence than the non-mulch treatments. The treatments without mulch had very poor emergence count, which was possibly due to crust formation owing to rainfall.

Generally, in soybean, soil moisture retention and porosity increases, bulk density decreases and aggregation improves with increasing amounts of straw mulch from 1 to 4 t ha^{-1}. Mulching results in cooler, moist soil environment (Munn, 1992). It has been reported that in soybean field the water potential in non-mulched soil increased, while the value in mulched soil with maize residue mulch did not increase even in the dry period of growth (Kitoh and Yoshida, 1996). The results of the present study are in agreement with the findings of other researchers (Singh and Jolly, 2008) who reported that the seedling emergence speed and final count of soybean increased and the decrease in emergence caused by rainfall was lessened, with straw mulch application.

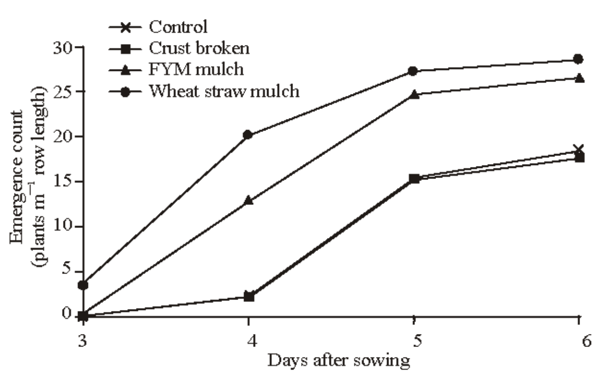

Fig. 1: Effect of different treatments on emergence of soybean

Both wheat straw and FYM mulches, when used to cover the rows of soybean only, improved emergence count (Fig. 1). Straw mulch decreases the crust strength by reducing the force of impact of raindrops. Furthermore, lower bulk density and soil strength and conservation of soil moisture by mulching with wheat straw as well as FYM could alleviate the reduction of seedling emergence through the surface soil crust formed by rain (Chaudhri and Das, 1980; Singh and Jolly, 2008). However, straw mulch application could have little effect on the emergence of legumes in some of the soils (Rahmianna *et al*., 2000). In case of control treatment, emergence was poor due to crust formation. Crust breaking was not an effective way of enhancing emergence (Fig. 1), as it might had damaged the emerging seedlings.

Effect on Weeds

Weedy check had the highest whereas two hand weedings done 30+45 DAS had the lowest dry weight of weeds (Table 3). Lower dry weight of weeds was observed in case of row mulch and plot mulch treatments compared to the weedy check, thus showing that mulching does, to some extent, check weed growth. Straw mulch is known to suppress weeds in soybean (Munn, 1992; Shilling *et al*., 1995). Dry weight of weeds was further reduced when straw mulching was integrated with herbicide pendimethalin. Weed Control Efficiency (WCE) of row mulch and plot mulch was 15.94 and 35.01%, respectively and it increased to as high as 58.60 and 72.55% when row mulch and plot mulch were integrated with pendimethalin 0.45 kg ha^{-1}. Higher WCE with plot mulch than row mulch might be due to covering of more surface area of ground with the former.

At harvest *Commelina benghalensis* was the most predominant weed species; in terms of count and dry weight it accounted for more than 90% of the total weed flora present in the experimental field. *Commelina benghalensis* was not controlled effectively with pendimthalin, that is why, plots sprayed with this herbicide also had considerably high weed dry matter. Moreover, some plants of this weed emerged at later part of crop growth when effect of pendimethalin had disappeared. Other weed species were very effectively controlled. Pendimethalin is a promising herbicide for effective weed control in soybean (Nayak *et al*., 2000; Jain *et al*., 2000; Galal, 2004). Non-mulched plots had quite high amounts of weed dry matter. This could be due to, apart from the above mentioned reason for pendimethalin treatments, low plant stand, which provided lot of space for weeds to grow in large numbers and profusely and thereby sparsely populated crop had no weed suppressing ability.

Effects on Grain Yield

Grain yield was significantly influenced by different treatments (Table 4). The combination of pendimethalin 0.45 kg ha^{-1} and plot mulch had the highest grain yield, which could be due to better plant stand as reflected in emergence count (Table 2), low crop-weed competition as it had less dry weight of weeds (Table 3), better crop growth as reflected in plant height and high number of pods $plant^{-1}$ (Table 4). The other treatments had low grain yields. The row mulch and plot mulch treatments had high emergence count and consequently high plant stand so in these treatments high weed dry matter was perhaps the main factor for low yields. In two hand weedings treatment, though weed dry matter was low but emergence count was poor, which could be responsible for low yields. In other treatments, low plant stand owing to poor emergence count and high weed dry matter might had resulted in low yields. The effects of straw mulch on improving yields of soybean are generally location-specific (Van Den Berg and Lestari, 2001).

Overall, grain yields were low, which could be due to (1) poor plant stand owing to rainfall before emergence, (1) presence of weeds as they were not removed due to the reasons stated above and (3) slightly delayed sowing; the optimum sowing time for soybean in Punjab is 1-15 June (PAU, 2009) and thus sowing done on the flag end of the recommended period might had resulted in low grain yields. All these factors, i.e., poor plant population (Arce *et al.*, 2009; Sincik *et al.*, 2009), presence of weeds (Singh and Jolly, 2004; Kumar and Das, 2008) and delayed sowing (Yunusa and Ikwelle, 1990; De Bruin and Pedersen, 2008; Egli and Cornelius, 2009) are known to reduce soybean yields drastically.

CONCLUSIONS

In Northern India sowing of soybean is generally done in June-July (AICRPS, 2004). In rainfed areas, due to failure of monsoon rain in June and July, sowing may be done even in August. Data show that during the sowing period (June-August) frequent rains are received (Table 1). Furthermore, temperature is also very high during these months (Table 1). The combination of these two factors results in conditions which are favourable for the formation of crust. As discussed above, crust formation reduces emergence (Fig. 1, Table 2), resulting in poor plant population and low grain yields (Table 4). The fear of low grain yields due to poor emergence owing to rainfall is one such factor which discourages the farmers to go for cultivation of soybean over large areas. The use of wheat straw as well as FYM mulches has shown promising results in improving the emergence count. Improved emergence count means optimum plant population, which provides higher grain yields.

In Punjab, Haryana and many other states in Northern India threshing of wheat is largely done by using combine threshers. The leftover wheat straw is generally burned, causing lot of pollution. This wheat straw can be very effectively used as a mulch material for soybean. In some areas mulching materials (wheat straw or FYM) may not be easily available. However, apart from mulching with straw or FYM as discussed above, some other techniques such as application of irrigation immediately before emergence or breaking soil crust by an improved crust breaking tool may also improve seedling emergence in a crusted soil. So the effects of these techniques on soybean emergence on fine- and coarse-textured crusted soils also need to be tested.

REFERENCES

AICRPS, 2004. Director's report and summary tables of experiments (2003-2004) of the all India coordinated research project on Soybean. National Research Centre for Soybean, Indore, India.

Arce, G.D., P. Pedersen and R.G. Hartzler, 2009. Soybean seeding rate effects on weed management. Weed Tech., 23: 17-22.

Chaudhri, K.G. and D.K. Das, 1980. Seedling emergence of summer legumes through simulated soil crusts. J. Indian Soc. Soil Sci., 28: 386-388.

De Bruin, J.L. and P. Pedersen, 2008. Soybean seed yield response to planting date and seeding rate in the Upper Midwest. Agron. J., 100: 696-703.

Egli, D.B. and P.L. Cornelius, 2009. A regional analysis of the response of soybean yield to planting date. Agron. J., 101: 330-335.

Galal, A.H., 2004. Effect of weed control treatments and hill-spacing on soybean and associated weeds. Acta Agron. Hung., 52: 81-93.

Jain, V.K., Y.S. Chauhan, M.K. Bhargava and A.K. Sharma, 2000. Chemical weed control in soybean (*Glycine max*). Indian J. Agron., 45: 153-157.

Kitoh, M. and S. Yoshida, 1996. Mulching effect of plant residues on soybean growth and physicochemical properties of soil. Jap. J. Soil Sci. Plant Nutr., 67: 40-48.

Kumar, M. and T.K. Das, 2008. Integrated weed management for system productivity and economics in soybean (*Glycine max*)–wheat (*Triticum aestivum*) system. Indian J. Agron., 53: 189-194.

Lee, B.W., Y.W. Kwon and E.J. Myung, 1996. Effects of soil crusting and hardening during drying after artificial rainfall on seedling emergence of rice and barnyard grass. Korean J. Crop Sci., 41: 131-138.

Munn, D.A., 1992. Comparisons of shredded newspaper and wheat straw as crop mulches. HortTechnology, 2: 361-366.

Nabi, G., C.E. Mullins, M.B. Montemayor and M.S. Akhtar, 2001. Germination and emergence of irrigated cotton in Pakistan in relation to sowing depth and physical properties of the seedbed. Soil Tillage Res., 59: 33-44.

Nayak, M.P., M.D. Vyas and K.S. Mandloi, 2000. Efficacy of pendimethalin in soybean (*Glycine max*). Indian J. Agron., 45: 162-165.

PAU, 2009. Package of Practices for *Kharif* Crops of Punjab. Punjab Agricultural University, Ludhiana, India.

Rahmianna, A.A., T. Adisarwanto, G. Kirchhof and H.B. So, 2000. Crop establishment of legumes in rainfed lowland rice-based cropping systems. Soil Tillage Res., 56: 67-82.

Shiel, R.S. and E.C. Yuriwo, 1993. Decreasing the impact of surface crusting on seedling emergence by wetting. Soil Use Manage., 9: 40-45.

Shilling, D.G., B.J. Brecke, C. Hiesch and G. MacDonald, 1995. Effect of soybean (*Glycine max*) cultivar, tillage and rye (*Secale cereale*) mulch on sicklepod (*Senna obtusifolia*). Weed Tech., 9: 339-342.

Sincik, M., A.T. Goksoy and Z.M. Turan, 2009. Soybean seed yield performances under different cultural practices. Turk. J. Agric. Fores. Sci., 33: 111-118.

Singh, S. and D.S. Kler, 1990. Modification of micro-environment with live mulch for optimizing seedling emergence and yield of soybean. Environ. Ecol., 8: 721-724.

Singh, G. and R.S. Jolly, 2004. Effect of herbicides on the weed infestation and grain yield of soybean (*Glycine max*). Acta Agron. Hung., 52: 199-203.

Singh, G. and R.S. Jolly, 2008. Improving emergence of soybean (*Glycine max*) with straw mulch and other practices under normal and crusted soil conditions. Acta Agron. Hung., 56: 275-283.

Van Den Berg, H. and A.S. Lestari, 2001. Improving local cultivation of soybean in Indonesia through farmers experiments. Exper. Agric., 37: 183-193.

Yunusa, I.A.M. and M.C. Ikwelle, 1990. Yield response of soybean (*Glycine max* (L.) Merr.) to planting density and row spacing in a semi-arid tropical environment. J. Agron. Crop Sci., 164: 282-288.