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Stale seed bed techniques as successful weed management practice

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Abstract
Weeds are competitive and adaptable to all the adverse environments. It has been estimate that in general weeds cause five percent loss to agricultural production in most developed countries, ten percent loss in less developed countries and 25 percent loss in least developed countries. Weed control by cultural and mechanical methods have some limitations as they are labourious, time consuming and expensive. Chemical weed control although is one of the effective method and have plagued with problems such as pollution of environment, development of weed resistance and above all is depend on fossil fuel. Stale seed bed is an eco-friendly alternate methods for weed control. Stale seedbed is based on the principle of flushing out germinal weed seeds prior to the planting of the crop, depleting the seed bank in the surface layer of soil and reduction of subsequent weed seedling emergence. In dry direct seeded condition SSB using glyphosate application @ 1 kg ha-1 was more effective in reducing the weed density and it recorded higher grain yield and B: C ratio than SSB using shallow tillage. The stale seedbed recorded significantly lowest dry weight of weeds, followed by soil solarisation and deep ploughing in groundnut. In corn cultivation, SSB by application of paraquat @ 0.5 kg/ha or glyphosate 2.0 kg/ha followed by pre-emergence use of either atrazine 3.0 kg/ha or pendimethalin 0.75 kg /ha before sowing gave better weed control. Stale seed bed technique should not be viewed as a stand-alone treatment that maintains weed suppression during the entire cropping cycle and thus may often require it be part of an integrated weed.

Keywords: Weeds, SSB using glyphosate, xenobiotic, stale seed bed technique, etc

Introduction
Achievements in the growth of agricultural productivity have been possible as a result of continuous influx of technologies into the agricultural production systems. Cultivation of high yielding crop varieties responsive to fertilizer and irrigation and the new intensive cropping systems have brought to the forefront the problem of weeds which cause tremendous losses to crops and their produce (Bond W. and Grundy A.C., 2001) [1]. Weeds are competitive and adaptable to all the adverse environments. It has been estimate that in general weeds cause five percent loss to agricultural production in most developed countries, ten percent loss in less developed countries and 25 percent loss in least developed countries (Oerke E.C. and Dehne H.W.,2004) [2]. Weeds have become one of the major deterrents in the development of sustainable intensive agriculture systems. Weed menace in agricultural field is ever increasing in spite of constants efforts to get rid of it (David *et al*., 2012) [3].

Weed control by cultural and mechanical methods have some limitations as they are labourious, time consuming and expensive (Kumar *et al*., 2012) [4]. Chemical weed control although is one of the effective methods, there has been a growing apprehension. Among ecologists about the use of chemicals which have plagued with problems such as pollution of environment, development of weed resistance and above all is depend on fossil fuel (Owombo *et al*., 2014) [5]. Hence, there is a need for developing eco-friendly alternate methods of weed control.

Globally, there is a growing need for non-chemical weed management tools due to:
- rapidly increasing herbicide resistance;
- a shrinking number of herbicides due to their withdrawal by regulators and chemical companies;
- growing consumer concern about herbicide and other pesticide residues in food and the environment;
- the growth of organic agriculture which prohibits the use of xenobiotic materials as inputs into farming systems.

Stale seedbed techniques

Stale seedbed may be defined as a seedbed prepared several days, weeks or months prior to sowing or planting a crop (Heatherly *et al.*, 1992) [6]. Stale seedbed is based on the principle of flushing out germinal weed seeds prior to the planting of the crop, depleting the seed bank in the surface layer of soil and reduction of subsequent weed seedling emergence Johnson W.C. and Mullinix B.G., 2000) [7].

The three 'golden rules' in SSB

There are three key pieces of scientific theory or 'golden rules' that underpin false and stale seedbeds.

1. Only 85-95% of seeds are dormant at any given time, but the 5-15% that are non-dormant, most germinate (very) quickly;
2. Tillage is the most effective means of getting weed seeds to germinate;
3. Most weeds can / will only emerge from top five centimetres / 2" of soil.

How to prepare a stale seedbed:

1. The area should be smooth and ready to plant
2. Irrigate area or wait for rain sufficient to germinate weeds
3. About 7 to 10 days after the rain or irrigation, perform shallow tillage with a rake, or hoe to kill the weeds. Also can spray with glyphosate herbicide (Roundup) to kill weeds.
4. Again irrigate or wait for rain sufficient to germinate weeds.
5. About 7 to 10 days after the rain, perform shallow tillage with a rake, or hoe to kill the weeds. Instead of tillage your can spray with glyphosate herbicide (Roundup) to kill weeds.
6. The area is now ready for planting.

Critical knowledge to ensure success

While the basic concepts of stale and false seedbeds are pretty simple, there are a number of factors that are critical to their success.

a. Tillage depth for false seedbeds - the most critical key for success
b. How long to delay planting
c. Getting perfect timing for stale seedbeds
d. Digging up the seeds
e. Accelerating germination
f. Higher seeding rates
g. Inspection, inspection, inspection
h. Being ready for immediate action

Stale seedbed method on direct-seeded rice

Stale seed bed technique (SSB) is another important cultural management strategy that can be used before any crop to reduce the weed seed bank. In SBB, weeds are allowed to germinate by giving a light irrigation or after a rainfall and after that emerged weed seedlings are killed using a non-selective herbicide like glyphosate or shallow tillage or flooding. The success of stale seedbed depends on several factors: method of seedbed preparation, method of killing emerged weeds, weed species, duration of the stale seedbed [8], and environmental conditions (e.g., temperature) during the stale seedbed period. Weed species, especially *Cyperus iria*, *Cyperus difformis*, *Fimbristylis miliacea* (L.) Vahl, *Leptochloa chinensis,* and *Eclipta prostrata*, are relatively more susceptible to the stale seed bed technique because of their low seed dormancy and their inability to emerge from a depth greater than 1 cm (Chauhan, B.S. and Johnson, D.E. 2008 and Chauhan, B. S. and Johnson, D. E. 2010).In dry direct seeded condition SSB using glyphosate application @ 1 kg ha-1 was more effective in reducing the weed density and it recorded higher grain yield and B: C ratio than SSB using shallow tillage (Singh, M.K. 2013) [10].

Sindhu PV *et al.*, 2010, Stale seedbed can also be implemented by submergence of rice field after 7 and 14 days of weed emergence. The initial seedbed preparation is then followed by destruction of the emerging weed seedlings with minimal soil disturbance. Stale seedbed method by glyphosate 1 kg/ha recorded more number of tillers and higher leaf area index in comparison to shallow tillage.

Stale seedbed method on groundnut

The highest branches/plant, pods/plant and 100-kernel weight were recorded under stale seedbed, followed by soil solarisation. Stale seedbed produced significantly the highest pod and haulm yields, followed by soil solarisation.

Effect of weed management on growth and yield attributes of groundnut

Treatment	Plant height (cm)	Branches/ plant	Mature pods/ plant	100-kernel weight (g)	Shelling (%)
Pre-sowing					
Deep ploughing	41.10	4.51	8.39	42.14	63.45
Stale seedbed	44.43	6.75	12.17	50.40	66.94
Soil solarisation	43.95	6.01	11.52	48.81	66.46
CD (P=0.05)	NS	0.39	0.55	1.97	NS

Effect of weed management on crop yield and weed parameters

Treatment	Pod yield (kg/ha)	Haulm yield (kg/ha)	Weed dry weight (kg/ha)	Weed index (%)	Weed control efficiency (%)
Pre-sowing					
Deep ploughing	907	1972	921	21.44	47.63
Stale seedbed	1118	2498	634	19.47	53.91
Soil solarisation	1086	2454	764	21.57	50.44
CD (P=0.05)	68	179	43		

The data indicated that the stale seedbed recorded significantly lowest dry weight of weeds, followed by soil solarisation and deep ploughing having WI of 19.47, 21.57 and 21.44%, and WCE of 53.91, 50.44 and 47.63%, respectively (Arora A and Tomar SS, 2012) [12]

Stale seedbed by herbicides

Adoption of SSB technique in lima bean field, the viability of weed seeds like *Digitaria sanguinalis* (L.) and *Cypreus* spp. were significantly reduced in upper two cm of soil and also count the viable *Poa annua* (L.) in the upper two cm and

Eleusine indica (L.) in upper most one cm soil were significantly reduced (Standifer L.C. 1980) [13]. The SSB technique reduced weed density and dry weight of *Echinochloa colonum* (L.) in direct sown rice compared with conventional seedbed preparation (Singh M.K. and Ashish Singh. 2012) [14].

Three successive applications of paraquat over a 39 day period prior to sowing the crop were necessary for effective weed control of *Eleusine indica* (L.) using the SSB technique of weed management ((Hawton D., 1980). In corn cultivation, SSB by application of paraquat @ 0.5 kg/ha or glyphosate 2.0 kg/ha followed by pre-emergence use of either atrazine 3.0 kg/ha or pendimethalin 0.75 kg /ha before sowing gave better weed control (Manuel *et al.*, 1980) [16].

Stale seedbed by tillage

The number of weed seeds and species diversity in the plow layer can be reduced by repeated tillage that stimulates emergence. Tillage affects weed seed emergence and survival through changes in soil conditions and redistribution of seeds in the soil profile. However, tillage also enhanced the germination of some weed seeds by several mechanisms *viz*., exposure of buried seeds to light, aeration of soil, increased soil temperature, removal of plant canopy and soil-bound volatile inhibitors and also by bringing the seeds to a more favourable site for germination (Evans R.A. and Young J.A., 1972) [17].

Whether the widely used tillage regime consisting of shallow tillage and ultimately deep tillage, is preferred above tillage practice depends on the proportion emergence specific for each soil layer, the proportion of seeds that is moved from one layer to the other, and the seed distribution in the soil. Soybean sowing, using stale seedbed techniques, by killing the first or second flush of weeds resulted in higher soybean yield (Jain K.K. and Tiwari, 1995) [18].

Effect of stale seed bed on weeds

Venkatakrishnan A.S. (1997) [19], Stale seed bed prepared 30 days before sowing significantly reduced the grasses, sedges and broad leaved weeds compared to conventional seed bed preparation in sesame cultivation. Stale seed bed can be an effective method of decreasing the density of annual weeds, as it has been demonstrated in many studies including weed control in maize production system (Leblanc M.L. and Cloutier D.C., 1996) [20]. The stale seed bed with cultivation was the second best treatment next to stale seed bed with glyphosate in comparison to conventional method. Stale seed bed is one of the weed management options that have the potential to reduce human labour and weed management cost. Stale seed bed formation is successful when most of the non-dormant weed seeds in the top 6 cm of the soil profile (Sanbagavalli S.,2001) [21].

Limitation of stale seedbed

Though the stale seedbed technique can be effective, like any weed management tactic there are some drawbacks. The population dynamics of weeds in response to stale seedbeds is hardly understood, and therefore stale seedbeds are possibly not optimized nor widely used at present. For example, in the absent of adequate rainfall, fields may require pre-irrigation events to initiate weed flushes.

The stale seedbed technique can be initiated several days, weeks, or months prior to seeding or transplanting a crop. If tillage is used to kill weeds that are flushed during stale seedbed techniques, this could result in more weed seeds being brought up to the soil surface. Stale seed bed technique should not be viewed as a stand-alone treatment that maintains weed suppression during the entire cropping cycle and thus may often require it be part of an integrated weed management (IWM) program.

Conclusion

Innovative approaches to control the weeds are in great demand around the world, particularly those which are cost effective and less harmful to environment. The search for such new control methods which are effective, economic and have minimal undesirable side effect is a continuous process. In recent years, with increased concern regarding the hazards of chemicals to the environment, interest in best weed management approaches, a key component of a well prepared stale seedbed is the absence of weeds at sowing/planting, as uncontrolled weeds at planting have the potential to significantly impair stand establishment and crop yields. The stale seedbed technique is a cultural practice that shows great potential as a viable component of an IWM program for conventional and organic crop production, and if properly orchestrated can improve weed control while lowering herbicide applications and overall production cost.

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