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Review Article

STALE SEEDBED TECHNIQUE OF WEED MANAGEMENT: A REVIEW

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Abstract- Weeds are the greatest menace in agriculture, which reduces the yield of crop by 10-90 per cent. Weeds are dangerous not only because of their competition for inputs, but also due to their survival capacity as per the old saying "one year seedling seven year weeding". The worst annual species are those having a high seed production and/or those producing seeds over a prolonged period of time. To reduce weed pressure it is important to prevent inflow of weed seeds from the environment. In stale seedbed land management practice, the weeds are stimulated to emerge and controlled by various measures prior to cropping. A key component of a well prepared stale seedbed is the absence of weeds at sowing, as well as uncontrolled weeds at sowing/planting have the potential to significantly impair stand establishment and crop yields. Often, many weed seeds in germination zone germinate and emerge before sowing thereby weed population is reduced during the cropping season. Stale seedbed (SSB) can be done between harvest and sowing and emerged weeds were controlled by tillage or foliar application of non-selective herbicides. Adoption of shallow tillage to kill emerged weeds in SSB method of weed control could result in a rapid depletion of the weed seed bank. Tillage helps to control weeds by killing the emerging seedlings, burying seeds, delaying growth of perennials and providing a clean uniform surface for efficient action of herbicides. However, weed populations could be reduced by utilising stale seedbed preparation to provide a less competitive environment for crops during earlier growth stages.

Keywords- Stale seedbed, Weed Control, Tillage, Herbicide

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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 [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 [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 [3]. Weeds by their manifold harmful effects on the growing crop plants and interference with lands, ranked prime enemies in crop production. Dormancy and longevity of weed seeds are natural mechanisms for the perpetuation of weed species on account of which it is impossible to deplete the soil weed seeds completely [4]. There is a tendency to regard weeds as an unavoidable problem in the farming.

Weed control by cultural and mechanical methods have some limitations as they are labourious, time consuming and expensive. Besides, these methods are employed only after the crop attained certain stage of growth, by this time the weed would have also grown sufficiently to cause damage to the crop plants by depriving them of nutrients, moisture, light and space [5]. 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 [6]. Hence, there is a need for developing eco-friendly alternate methods of weed control. Consequently, researchers in their search for new methods also took interest in some of the traditional practices with a hope of evolving a much efficient tool of weed management. The time demands that the new methods besides, being efficient, economically viable, ecologically sound and acceptable to the users and environmental friendly [7].

In general, weed density is very high at early growth stage to critical period of crop weed competition. Therefore, new approaches are needed to reduce weed problems before sowing or crop emergence [8]. In this direction, weed populations could be reduced by utilizing stale seedbed preparation to provide a less competitive environment for crops during earlier growth stages. SSB technique system is to improve the weed growth before crop sowing or planting by means of early soil tillage and weeds controlled by secondary tillage or using non-selective herbicides [9]. Several environmental cues, including day/night temperatures, moisture, oxygen levels, and light exposure, trigger the germination of weed seeds. A stale seedbed is formed either when the field is prepared for sowing/planting nor weeds are allowed to germinate during the fallow period and also it could be encouraged by irrigation. The germinating weeds were controlled by either tillage practices or spraying of broad spectrum of herbicides [10]. After a few weeks (usually 2 weeks or more) the emerged weeds are killed before sowing/planting. By limiting soil disturbance when the emerged weeds are killed,

buried seeds are not exposed to light and other stimuli that encourage germination, and emergence of new weed seedlings is less likely to occur [11]. Stale seedbed method should be flexible enough, to incorporate innovation and practical experiences of local farmers, developed for the whole farm and not for just one or two fields and hence it should be extended to other non-crop surroundings on the farm from where most weeds find their way into the crop fields and economically viable and practically feasible.

Stale seedbed techniques

Stale seedbed may be defined as a seedbed prepared several days, weeks or months prior to sowing or planting a crop [12]. 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 [13]. In no tillage, weed germination will be more sporadic and extended over a long period of time. The land is brought to fine tilth by repeated cultivation before the receipt of pre monsoon showers to provide favourable conditions before sowing of crops. This is known as 'stale seedbed'. Generally, the effectiveness depends on occurrence of pre monsoon showers and if pre monsoon showers are not received crops and weeds sprouts together resulting in higher weed intensity. Weed intensity is usually low in late sown crop than early sown crop because of stale seedbed effect on weeds.

Objectives of stale seedbed technique

Through SSB method, weed seeds in the surface layer of the soil are induced to germinate and emerge before cropping so that a part of weed population could be eliminated by pre-plant shallow tillage or by post emergence herbicide spray. Foliar application of non-selective, non-residual herbicides like glyphosate controls existing weeds before or at the time of sowing which results in reduced weed population in the cropped field. Adoption of shallow tillage to kill emerged weeds in SSB method of weed control could result in a rapid depletion of the weed seed bank. Tillage helps to control weeds by killing the emerging seedlings, burying seeds, delaying growth of perennials and providing a clean uniform surface for efficient action of herbicides [4]. This technique reduces weeds emergence [15], delaying early crop-weed competition and also reduces weed seeds bank [16]. The achievement of stale seedbed be contingent on various factors such as environmental condition, type or method and duration stale seedbed preparation, how to killing the emerged weeds, weed species, dormancy period of weeds and type of non-selective herbicides [17].

Stale seedbed by herbicides

Stale seedbed (SSB) approach can be used to ensure timely planting on clay soils and early, timely sowing/planting can result in higher net return when irrigation is given in dry season. Stale seedbed planting can be done following fall tillage, spring tillage or no tillage between harvest and planting and use of pre-emergence foliar application of 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 [18]. The SSB technique reduced weed density and dry weight of *Echinochloa colonum* (L.) in direct sown rice compared with conventional seedbed preparation [15]. 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 [19]. 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 [20]. The application of gramoxone in stale seedbed plots reduced the population of Phalaris *minor* in wheat field [21].

In rice, performance of anilofos, and pendimethalin both at 1.5 kg /ha as pre-emergence was considerably improved under SSB [22]. Application of glyphosate (560 g /ha) to stale seedbed resulted in 90 per cent control of hemp sesbania and increased soybean yield (1270 kg/ha) compared to paraquat application at 420 g/ha [23]. Stale seedbed system to determine the effect of time of herbicide application on weed control and soybean yield. Application of herbicide 2 to 5 weeks before sowing (WBS) generally controlled common cockle bur (86 per cent) and pitted morning glory (84 per cent) and recorded the yield of 1564 kg/ha compared to a yield of 1394 kg/ha with pre-plant herbicide applied at 6 and 7 WBS (67 per cent and 72 per cent of control respectively) and recorded the yield of 1394 kg /ha [24].

Application of herbicide mixture metribuzin 360 g/ha + chlorimuran 60 g/ha as tank mix with 700 g /ha of paraquat at 2 to 4 leaf stage of weeds in SSB controlled the sickle pod (*Cassia obtusifolia* (L.) and pitted morning glory (*Ipomoea lacunosa*) by 83 and 91 per cent respectively at 4 weeks after sowing of soybean [25]. SSB prepared 40 days before sowing of soybean with the application of glufosinate (840 g/ha) was as effective as glyphosate or paraquat (1.12 kg/ha) for pre-plant control of weeds [26]. Adoption of stale seed bed in field, the viability of weed seeds like *Digitaria sangunalis* and *Cyperus rotundus* were significantly reduced in upper two cm of soil [18].

Sickle pod (*Cassia obtusifolia*) under SSB was better controlled with post emergence herbicides *viz*., glufosinate at 710 g/ha (81 per cent) or paraquat 420 g/ha (87 per cent) compared to glyphosate 420 g/ha (44 per cent) in soybean [27]. He also suggested that tank mix application of paraquat + imazaquin (140 g/ha) for stale seedbed preparation gave the highest soybean yield (1070 kg /ha) than imazaquin alone (601 kg /ha). SSB in cotton to assess the impact of pre-plant incorporation of herbicides at 0 to 8 weeks before planting (WBP) in silt loam soil and concluded that many herbicides can be used without causing crop injury at 0 to 4 WBP [28]. SSB prepared for sowing of cotton crop, using non-selective herbicides like glufosinate 1.2 kg /ha, glyphosate or paraquat at 1.96 kg /ha alone gave less than 70 per cent of sickle pod control at two weeks after sowing but when non-selective herbicide was tank mixed with diuron, sicklepod control was more than 80 per cent [29]. Field experiment in soybean with SSB plots between 1988-1990 and the results showed that SSB with glyphosate (0.84 kg/ha) + cultivation alone was not adequate for soybean and that either pre or post emergence herbicides were required to get maximum seed yield and found that yellow nutsedge was not seen at the end of experiment [12]. Pre plant application of glyphosate 2.0 kg /ha + 2 per cent ammonium sulphate at 20 days before planting of sugarcane controlled the population of *Cyperus rotundus* (L.) very effectively [30]. Similarly, [31] reported that glyphosate use in stale seedbed lettuce provided better weed control than mechanical tillage. Stale seedbed in combination with paraquat on weeds in irrigated cotton and found that weed pressure could be reduced by 52-54% [32]. The stale-seedbed in combination with herbicides was a superior integrated weed management tool compared with conventional weed management practices.

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 [33]. Systematically examined the effect of seedling emergence and subsequent weed control on weed population dynamics, starting by considering the seed bank as one soil layer, and continued by considering a depth-structured seed bank [23]. 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 [15]. Soybean sowing, using stale seedbed techniques, by killing the first or second flush of weeds resulted in higher soybean yield **[34]** Adopting stale seedbed techniques either for 7 or 14 days (by keeping field drained and destruction of weeds by letting in water on 14th day) significantly reduced the population of grassy and broad leaved weeds and improved grain and straw yield of wet seeded rice compared to normal seed bed [16]. SSB by shallow tillage improved the weed control in cucumber and recorded lowest density of

florida purseley (*Richardia scabra* L.) and yellow nut sedge [35].

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. Tillage was one of the most effective methods for controlling small annual weeds having growing points closer to ground [36]. In Tiftan, USA, [37] found that SSB by shallow tillage reduced the density of yellow nutsedge (*Cyperus esculentus* (L.)), florida beggar weed (*Desmodium tortuosum*) and texas panicum (*Panicum texanum*) in peanut field. In wheat crop, SSB achieved by light irrigation at 15 days before sowing (DBS) and killing the emerged weeds by working bullock drawn blade harrow before sowing and application of isoproturon 1.0 kg/ha as pre-emergence resulted in weed control efficiency of 34 per cent and recorded a yield of 4270 kg/ha compared to 4064 kg/ha with normal seedbed [38].

Absence of pre-plant tillage in soybean led to the presence of early germinating summer annual weeds including *Conyza canadensis, Polygonum lapathifolium* and *Aster exilis*. Some perennials *viz*., *Rumex crispus* (L.) and *Paspalum distichum* (L.) increased in SSB areas where pre-emergence herbicides were not used [39]. Pitted morning glory controlled (80 %) under SSB by tillage and 83 per cent by using glyphosate [23]. Use of stale seed bed tillage as a cultural weed control practice has the potential to improve weed management [13].

Yield increase of sesame under SSB by tillage was 48 per cent over conventional method of land preparation [40]. SSB (deep tillage 6 weeks before planting) and glyphosate 1.1 kg/ha, applied at one week before sowing of peanut had lower weed density of texas panicum (*Panicum texanum*) and florida beggar weed (*Desmodium tortuosum*) compared to shallow tilled system [37]. SSB by cultivation (seedbed prepared 30 DBS) significantly reduced the grasses, sedges and broad leaved weeds compared to the conventional seedbed preparation in sesame cultivation [41]. Early removal of weeds from the stale seedbed (false seeding) can contribute to decreasing weed presence in following stages of crop in the field [42].

Effect of stale seed bed on weeds

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 [41]. 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 [43]. Adoption of stale seed-bed practice caused reduction in weed count (18.8-34.1%) and dry weight (21.3%) as compared with that of conventional tillage - flat bed [44]. Stale seed bed technique followed by inter cultivation twice at 20 and 35 DAP significantly lowered the total weed density and weed dry weight (23.9 No./m^2 and 10.3 g/m^2) and was at par with hand weeding twice at 20 and 30 DAP (22.6 No./m^2 and 9.4 g/m^2, respectively) in finger millet [45]. 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 [46]. The optimum timing for stale seed bed preparation was 20 to 30 days before planting which provided adequate weed control and resulted in optimal yield [47].

Effect of stale seedbed on yield of crops

Stale seedbed was found to be a highly effective weed-preventive practice in cereal grains, peas, brassicas, and other cool season crops [29] Early removal of weeds from the stale seedbed (false seeding) can contribute to decreasing weed presence in following stages of crop in the field [42].

The optimum timing for stale seed bed preparation was 20 to 30 days before planting which provided adequate weed control and resulted in optimal yield. All stale-seedbeds, with the exception of the 40 days before sowing/planting stale-seedbed, had greater yields compared with the control (0 days before sowing/planting) seedbed [47]. The optimal timing of stale-seedbed preparation was 20 to 30 days before sowing/planting [48]. Adopting stale seedbed techniques either for 7 or 14 days before sowing significantly reduced the population of grassy and broad leaved weeds and improved grain and straw yield of wet seeded rice compared to normal seed bed [14]. Yield increase of sesame under stale seed bed by tillage was 48 percent over conventional method of land preparation [49].

Stale seedbed formation is successful when most of the non-dormant weeds in the top six centimeter of the soil profile emergence and are killed before crop sowing/planting. The depleted weed seed bank in the germination zone reduced weed pressure in the crop [50].

Peanut yield increased with inclusion of stale seedbed tillage as a cultural weed control practice has the potential to improve weed management. [13] Similarly, peanut yield were generally greater in plots with tilled stale seedbeds than in the non - tilled control [51].

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. Questions pertain to how seedling emergence from the seed bank affects the weed population and how tillage affects seedling mortality and emergence. For example, in the absent of adequate rainfall, fields may require pre-irrigation events to initiate weed flushes. Finally, under certain conditions, especially when dealing with “wimpy” or less competitive (e.g., small and slow growing) crops, multiple weed flushes over time may be required before planting the crop to effectively prevent weeds from competing with the crop after sowing/planting. Because the standing weed seed bank and soil conditions will differ from field to field, the optimal waiting period between pre-plant irrigation and final killing of weeds may not be known. 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.

Author contributions

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