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Weed management in wheat through zero tillage and herbicides: A review

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Abstract
Wheat is the most extensively grown food crop and a staple food for the majority of the world's population. At the same time, wheat is the most reliable crop in the country and is necessary for the country's nutritional security. But, one of the primary factors limiting wheat output and productivity is weed infestation. Weeds in crop fields not only compete with standing crops for nutrients but also for light, water, air, space and micro environment and thus, reduce the quantity and quality of agricultural produce. Weeds can reduce yields to a greater extent depending on the density and dynamics of the weeds. Effective weed management plays a crucial role for the growers aiming at minimizing labour demand and production costs. It can be achieved through adopting integrated weed management (IWM) in which weed flora population can be eliminated by using various suitable management practices against weeds i.e. hand weeding, mulching, hoeing or integration of herbicide can control weed effectively during critical period of crop weed competition. Considering all these facts this article summarizes effect of tillage and herbicides on weed growth and yield of wheat.

Keywords: Tillage, weed, herbicide, wheat

Introduction
Weeds have been a problem since the dawn of agriculture. Weed management is coordinating efforts to control weeds in crops in order to selectively reduce weed competition, allowing crops to make the most use of resources such as soil fertility, water and sunshine to achieve the highest harvestable crop yield. According to Kumar *et al.* (2010) [21] yield reduction due to weeds in wheat crop ranges from 17 to 50%. Hence, it is very much appropriate to get the sight of the historic trend of weed infestation, dynamics and chemical management in wheat in India to not only understand the loopholes of the past in terms of weed management, but also to tackle the intensifying problem of weeds in wheat in present as well as in future. Gul *et al.* (2006) [12] suggested that ZT as a resource conservation technology has optimum potential to reduce production costs, enhance efficiency of natural resource management practices, exploit potential of the rice-wheat system and there by benefits the environment.

Weed flora in wheat
Wheat weed flora varies per field due to environmental factors such as irrigation, fertiliser usage, soil type, weed management tactics and cropping sequences. Various research workers have described the diverse nature of weed flora throughout the wheat growing regions of the country and abroad. In West Bengal winter is short and mild in nature. Wheat is mainly grown after *kharif* rice. The. The leading weeds species like *Alternanthera sessilis, Chenopodium album, Cynodon dactylon, Digitaria sanguinalis, Eclipta alba, Gnaphalium indicum, Polygonum plebeium, Rumex acetosella, Vicia hirsute* (AICRP-WC, 2003) [2] constitute the vast weed flora of wheat in Birbhum district of West Bengal. According to Rahaman and Mukherjee (2009) [31] predominant weed flora seen in the weedy plots were *Polygonum orientale, P. pensylvanicum, P. persicaria, Stellaria media, S. aquatica, Oldenlandia diffusa, Hydrocotyle ranunculoides*, *Physalis minima, Eclipta alba*, *Cynodon dactylon*, *Setaria glauca* and *Digitaria sanguinalis*.
Singh *et al.* (2010) [35] stated that *Echinochloa colona, Cynodon dactylon, Alternanthera triandra, Melilotus indica, Chenopodium album, Melilotus alba, Anagallis arvensis,* etc. Were the major weed floras in *zero* tillage wheat fields. Grasses were lesser in number compared to broad leaf weeds like *Melilotus indica* and *Chenopodium album* in wheat field. Tuti and Das (2011) [42] reported that major weed flora at the experimental plot of wheat consisted of *Chenopodium album*, *Melilotus indica* among broad-leaved weeds and *Phalaris minor*, *Avena sterilis* sub sp. *Ludoviciana* among grasses and *Cyperus rotundus* among sedges.

Kien *et al.* (2016) [19] observed that major weed flora at the experimental field comprised of broad-leaf, sedges and grassy weeds. In weedy check at 90 DAS, broad-leaved weeds dominated the experimental site, accounting for 78.2 percent of density and 71.9 percent dry matter of total weeds. Pawar *et al.* (2017) [30] stated that weed flora was dominated by grassy weeds viz., *Phalaris minor*, *Avena ludoviciana* while, *Chenopodium album, Rumexs spinosus*, *Coronopus didymus*, *Melilotus alba* and *Polygonum plebeium* were among broad-leaved weeds.

Crop-weed competition in wheat

Weeds compete with crop for nutrient, moisture light and space eventually cause reduction in yield. The morphological similarity of weeds with crop is prime factor in determining the crop weed competition and its effect on crop yield. According to Verma *et al.* (2008) [43] weed infestation throughout crop growth period resulted 43.63% reduction in grain yield of wheat. Over the rest of the weed control strategies, the season-long weed-free environment produced considerably greater grain production (3.57 t ha-1), yield characteristics, nutrient absorption, and weed control efficiency. Singh *et al*. (2013) [39] reported that the crop weed competition was distinctly reduced by weed control treatments as is evident from the substantial decrease in weed population, dry matter accumulation, weed killing efficiency, weed control efficiency and weed control index by 6.1%, 41gm^{-2}, 38.1%, 67.4%, -23.5%, respectively. A significant reduction in grain yield and yield attributes were observed when weeds were allowed to grow beyond 50 days after sowing.

Meena *et al.* (2016) [25] observed that the maximum NPK (164.62:35.46:127.1) kg ha^{-1} uptake by wheat was registered by application of sulfosulfuron + metsulfuron (30+2 g ha^{-1}) and minimum uptake of NPK (0.60:0.16:0.42) kg ha^{-1} by weed were noted in same treatment. Maximum uptake of NPK by weed and minimum uptake by wheat was registered under weedy check treatment (6.04:2.06:5.97) and (92.60:19.30:81.6) kg ha^{-1}, respectively.

Some common annual weeds present in the cropped areas transpires about four times greater amount of water than a crop plant and utilize up to three times as much water to produce a unit of dry matter as do the crops For instance, the consumptive use of water in Chenopodium album was reported to be 550mm, compared to 479 mm for wheat (Hasanuzzaman, 2008) [13]. Further, under water stress condition, weeds are able to decrease crop yields by more than 50% through moisture competition alone.

Yield losses caused by weeds in wheat

Duary and Yaduraju (2005) [8] informed that the yield reduction in wheat due to *P. minor* alone was to the tune of 29.0-32.6% with the *P. minor* density of 200m^{-2}. According to Chopra *et al*. (2008) combined population of grass and broad-leaf weeds showed 25.7 % reduction in wheat seed yield in uncontrolled weedy check. Sharma (2009) [33] from Bikaner, Rajasthan opined that uncontrolled weeds caused 58.3% loss in the wheat grain yield. Weeds caused 40.25% loss in grain yield of wheat compared to weed free plots (Bharat and Kachroo, 2010) [3]. According to Katara *et al*. (2012) [16] weeds resulted in grain yield of wheat to the extent of 39.5%. Losses in crop yield caused due to weeds in wheat is found to be 5.91 t ha^{-1} in weed free, 4.04t ha^{-1} in weedy plot and total loss is 31.6% (Yadav *et al*., 2018) [45].

Zero tillage in wheat

Zero tillage (ZT) is gaining popularity within farmers because it significantly reduces production costs relative to conventional tillage. Zero till sowing has reduced the volume of irrigation water required for wheat in north-west India thus reduced the cost of cultivation (Erenstein and Laxmi, 2008 and Erenstein *et al.*, 2008) [9, 10]. Kumar *et al.* (2016) [20] reported that maximum growth of different micro-organisms was witnessed in zero tillage system, whereas minimum was in conventional tillage system.

Early wheat showing has established a positive impact on wheat yield by mitigating the negative effect of terminal heat stress (Kumar *et al*. 2018, CSISA, 2015) [22, 4]. Due to the obvious and good impacts of ZT technology in wheat on productivity, profitability, resource usage efficiency and terminal heat stress resilience (Keil *et al*. 2015, Erenstein and Laxmi, 2008) [9], ZT wheat has been widely adopted in north west India (*e.g.* 0.26 M ha in Haryana state alone) and now it is gaining approval in the eastern Indo-Gangetic Plains (CSISA 2015, CSISA 2016, CSISA 2017) [4, 5, 6]. In India, gradual increase in the area of zero-till (ZT) wheat in the rice-wheat system of the IGP has been observed in last two decades, mainly, due to locally developed farm machineries and availability of suitable herbicides (Jat *et al*., 2012) [15].

Weed population dynamics under zero and conventional tillage

Zero-tillage practices register significantly fewer weeds, compared to conventional tillage. Ahmed *et al.* (2004) [1] also found that the most noxious weeds existing during the first year were not observed in the last year. *C. rotundus* and *P. minor* disappeared particularly in the zero-tillage fields over the passing years and broadleaf weeds like *M. indica* and *R. dentatus* were predominantly seen under conventional tillage system. Mishra *et al.* (2005) [28] concluded that the wheat field was infested mainly with *Chenopodium album* (88.6%) and *Physalis minima* (85%). Zero tillage resulted in reduction of population of both the weed species as compared to conventional tillage. Higher weed spread with conventional tillage than zero tillage may be due to better tilth and exposure of weed seeds to the top soil. (Sinha and Singh, 2005) [41]. Singh (2008) [36] reported that number of weeds recorded were substantially low in zero tillage system as compared to conventional system at all the sites. According to Franke *et al*. (2007) [11] emergence rate of all three flushes of *Phalaris minor* in wheat sown on the same date were lower in ZT compared with CT. The most critical flush impacting crop-weed competition, the initial emerging flush, was roughly 50% lower in ZT than in CT. Dev *et al.* (2013) [7] concluded that density and dry matter accumulation of weeds in no tillage was significantly lower than conventional tillage.

Yield advantage under zero tillage

Wheat sowing by reduced tillage gave considerably increased grain yield than conventional method (Mangat *et al.*, 2006) [24]. The maximum average grain and biological yield was obtained under ZT weed free situation which was at par with CT and the highest harvest index was obtained in zero tillage weed free which was remarkably superior to the conventional tillage system (Singh *et al*., 2001) [38]. According to Mishra *et al.* (2005) [28] ZT produced highest grain yield of wheat followed by CT and FIRBS. Rautary (2002) [32] concluded that grain yield of wheat in rice-wheat system was greater in ZT than CT.

According to Singh (2014) [40], ZT system of wheat sowing recorded highest number of tillers and grain yield over CT. Meena, (2010) [16] estimated that zero tillage recorded significantly higher grain (4.31 tonnes ha^{-1}) and straw yields (6.46 tonnes ha^{-1}) of wheat, which was higher to the extent of 7.13 and 5.21% over the conventional tillage. Sowing of wheat by zero-till seed drill gave higher total productivity in comparisons to conventional tillage practices (Mishra and Singh, 2007, Singh *et al*., 2002) [14, 34].

Chemical weed management

Herbicides and herbicide mixture

Jain *et al.* (2007) [14] reported that maximum benefit cost ratio was obtained with zero tillage along with application of clodinafop followed by 2, 4-D. According to Om *et al*. (2006) [29] clodinafop + metsulfuron 60+4 g (PoE) can effectively control various weed flora in wheat According to Verma *et al.* (2008) [43] higher grain yield of (2.97 t ha^{-1}) was obtained with the post emergence application of sulfosulfuron in comparision to isoproturon and pendimethalin. Yadav *et al.* (2009) [47] found that density and dry weight of *Phalaris minor* under ready mix formulation of clodinafop + metsulfuron 64 g ha^{-1} were equal with clodinafop alone 60 g ha^{-1}, sulfosulfuron 25 g ha^{-1}, clodinafop fb metsulfuron 60 and 4 g ha^{-1}, clodinafop + carfentrazone 60 + 20 g ha^{-1} and sulfosulfuron + metsulfuron ready mix at 32g ha^{-1}. All the ready mix doses of clodinafop + metsulfuron provided effective control of weeds. As a result of which, clodinafop + metsulfuron (ready mix) 64 g ha^{-1} produced grain yield similar to weed free check during both the years.

Malik *et al.* (2013) [23] stated that clodinafop 60 g ha^{-1} was quite effective (95-98%) only against grassy weeds. Metsulfuron 4 g ha^{-1} was pretty effective (88-90%) only against broad-leaf weeds. Sequential application of clodinafop 60 g ha^{-1} *fb* metsulfuron 4 g ha^{-1} being statistically at par with ready mixed herbicide clodinafop-propargyl + metsulfuron-methyl at 60 + 4 g ha^{-1} and above seemed much effective against complex weed flora and the control of grassy and broad-leaved weeds to the tune of 95%. Kaur *et al.* (2015) [18] also reported similar results.

According to Walia *et al.* (2010) [44] carfentrazone + sulfosulfuron at 36, 45 and 54 g ha^{-1} either with 625 ml or 750 ml ha^{-1} of surfactant performed at par with sulfosulfuron 25 g ha^{-1} and sulfosulfuron + metsulfuron with respect to reduction in dry matter accumulation by *Phalaris minor* or broad leaf weeds and production of increased grain yield of wheat.

Kumar *et al.* (2012) at Dehradun, Uttarakhand stated that clodinafop-propargyl + metsulfuron-methyl (60+4 g ha^{-1}) applied as post-emergence produced 14.3, 15.5, 23.7, 29.5, 45.9, 47.4 and 69.7% increased grain yield over pendimethalin, isoproturon + metsulfuron methyl, fenoxaprop-p-ethyl + metsulfuron methyl, fenoxaprop-p-ethyl, isoproturon, clodinafop propargyl and weedy check, respectively. Kaur *et al.* (2016) [17] reported the application of clodinafop-propargyl yielded substantially higher grain yield over the weedy check. According to Singh *et al*. (2016) [37] post emergence application of fenoxaprop (Whip super) standard check 120g and Topic (clodinofop) 60 g ha^{-1} (standard check) resulted considerably higher yield under delayed sown wheat. These findings were substantiated with the results obtained by Yadav *et al*. (2009) [47].

To deal with the major problem of herbicide resistance, tank-mix or sequential application of herbicides would be a better alternative than their application alone in case of P. minor in wheat (Yadav *et al*., 2016) [46]. Pawar *et al.* (2017) [30] reported that pre-mix application of pinoxaden 2.53% + clodinafop propargyl 2.53% at 50-60 g ha^{-1} at 35 days after sowing was much effective in controlling *Phalaris minor* and *Avena ludoviciana* and also produced even higher grain yield of wheat.

Conclusion

Wheat cultivated with zero tillage having herbicidal use has considerable farm-level benefits, including increased production improvements, fuel savings and lower input costs. Following that, better returns were also achieved.

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