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IMPACT OF FERTILIZER USE ON WEED MANAGEMENT IN CONSERVATION AGRICULTURE - A REVIEW

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ABSTRACT:- Intensive farming has been adopted to produce large amounts of food grains and cash crops but environment is being deteriorated at alarming rate also. Increased use of fertilizers, pesticides, chemical growth regulators, machinery and poor management practices are accelerating environmental pollution, soil degradation, global warming, climatic change and food deterioration. Conservation agriculture offers a sustainable solution for all these problems most often. This review focuses the use of fertilizers in conservation agriculture and their impact on weed management. Weeds are major constraint in the productivity of agro-ecosystems. Fertilizer use can influence weed emergence, weed persistence, weed dormancy, weed dynamics, weed growth and weed dispersion attributes. The rate, timing, type and method of fertilizer application affect biological trends of weeds. In conservation tillage systems, the interaction between fertilizers and weeds is very complex, and there are reports of positive as well as negative correlations with weed establishment. Altered physical and chemical properties of reduced-tillage soils result in different weed growth and weed-crop competition periods and thus have indirect impacts on weed control strategies and management options in conservation crop production.

Key Words: Conservation Agriculture; Fertilizer Use; Weed Dynamics; Weed Management; Pakistan.

INTRODUCTION

Nutrition is very important aspect in any cropping system and its importance in conservation agriculture (CA) is even more. Fertilizer use has definite influence on weed emergence, weed persistence, weed dormancy, weed dynamics, weed growth and weed dispersion attributes. It is imperative to study such interactions in depth to develop safe and pragmatic approaches for weed management in sustainable agriculture. Proper management of crop nutrients assures the sustainable weed management through provision of suitable inputs for crop functioning. It promotes a healthy competition in which participation of plants is strong and thus better growth habits are developed. Crop production practices such as tillage, weed management, and fertilizer application, influence weeds in agriculture (Barberi et al., 1997). Fertilizer is any material or substance applied to the plant for the provision of essential nutrients for their better growth and development. There are different forms of fertilizers

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that can be used according to the crop requirements. There might be inorganic and organic fertilizers in simple or compound form. Unless controlled properly, weeds are major users of nutrients applied to crops.

Conservation agriculture has resulted in improved fertilizer efficiency (10-15%) in the rice-wheat system, mainly a result of better placement of fertilizer with the seed drill as opposed to broadcasting with the traditional system (Hobbs and Gupta, 2004). In some reports, nitrogen fertilizer efficiency was recorded as lower, a result of microorganisms tying up the nitrogen in the residue. However, in other longer-term experiments, release of nutrients increased with time because of more active microbial activity and nutrient recycling (Carpenter-Boggs et al., 2003). Most of the time weeds are more effective than crop plants in obtaining nutrients in soluble form (Moody, 1981). Many studies have explored crop nutrients requirement and the dose requirements for high crop yield. It is necessary to predict the possible fertilizer doses at which crops may get maximum advantages leaving weeds fragile. Mohammaddoust-e-Chamanadad et al. (2006) indicated that nitrogen, phosphorus, and potassium (NPK) are primary macro nutrients required for the crop. These nutrients are vital in plant functioning and structure. They improve crop yield due to optimum growth of plants.

Most of the work done on fertilizer, weed interaction is general irrespective of the nutrient status. Many scientists have studied effects of nitrogen, phosphorus on weeds. Nitrogen is the 1st nutrient to become limiting as a result of weed crop competition (Moody, 1981). Very few studies have been conducted to explore the role of potassium in this regard. Role of nutrient management in weed control is very important in CA because manual control is not feasible at larger scale. Delicate interactions between weed behaviors and nutrient dynamics play vital role in system sustainability. This relationship is even more significant in conservation agriculture and requires special attention for future progress.

WEEDS RESPONSES TO FERTILIZERS

Weeds show variety of responses to different fertilizers under different tillage systems depending upon rate and method of application. Sensitivity of weeds to fertilization depends on their responding ability in terms of weed growth and nitrogen assimilation. As reported by Blackshaw and Brandt (2008), some weed species (e.g. *Persian darnel* and *Russian thistle*) exhibited minimal response to N, few (e.g. Redroot pigweed) showed high response as N application rate increases, while very few weed species like wild oat did not affected by any N fertilization level. Nutrients availability influence weed crop competition (Evans et al., 2003), however response varies with type of weed species, crop and nutrient status of soil. Weaver et al. (1992) reported nutrients availability as one dynamic approach that can influence duration and extent of competition. Moreover, environmental factors influencing the efficacy and efficiency of fertilizers affect weed dynamics and distribution. Sweeney et al. (2008) studied the effect of N on weeds emergence and growth parameters. Results have shown that N influenced the germination, emergence and competitiveness of different weeds. In some reports, nitrogen fertilizer efficiency was recorded as lower, a result of microorganisms tying up the nitrogen in the residue. However, in other longer-term experiments, release of nutrients increased with time because of more active microbial activity and nutrient recycling (Carpenter-Boggs et al., 2003). Lindsey et al. (2013) examined the aggressiveness of Redroot pigweed and Lamb-squarter towards nitrogen assimilation at various nitrogen levels. Fertilizers may increase the biomass of weeds in fields where its density is already high or they may enhance the density directly through provision of essential nutrients for germination, emergence and establishment of weeds (Alkamper and Long, 1978). But some long term studies have shown contradictory results showing that increased nutrients level reduced the weed abundance but increased their dry matter (Mohammaddoust-e-Chamanadad et al., 2006).

FERTILIZER USE EFFICIENCY AND WEED MANAGEMENT

The fertilizer use efficiency (FUE) in an agricultural system is based on four factors, namely accurate dose of fertilizer having balanced nutrient percentage, safe and precise method of fertilizer application, appropriate timing for application and crop specific fertilizer selection. As suggested by DiTomaso (1995), manipulating fertilization strategies reduces weed interference in crops. Varying fertilizer doses (Cathcart and Swanton, 2003), application timings (Blackshaw et al., 2004) and methods (Mesbah and Miller, 1999) can modify weed crop competition.

FERTILIZER TYPE AND DOSE

Fertilizer type and dose influence the emergence (Table 1). Ferti-

Table 1. Effect of fertilizer type and dose on weed emergence

Element	Fertilizer	Dose (kgha^{-1})	Seeds emerged (m^{-2})	
			Corn spurry	Shepherd's purse
N		0	155 ^{c}	163 ^{a}
	Ammonium nitrate	200	200 ^{a}	146 ^{b}
	Urea	200	170 ^{b}	166 ^{a}
P		0	163 ^{b}	146 ^{b}
	Triple super phosphate	65	184 ^{a}	170 ^{a}
K		0	164 ^{b}	155 ^{a}
	Muriate of potash	125	186 ^{a}	161 ^{a}

Means followed by same letter do not differ significantly at P ≤ 05. Source: Freyman et al., 1989.

lizer levels especially nitrogen can alter crop weed interactions significantly in terms of inhibition and promotion (Cathcart and Swanton, 2003). It affects overall weed abundance depending upon type (Table 2). At proper rate, weeds can be controlled by reducing extra nutrients, not taken by plants. Besides this, weeds performed different under different fertilizer regimes. In a study, it was reported that total weed biomass increased with increasing N application rate (Guza et al., 2008). Application rate should be according to crop requirement and prevailing conditions (Major et al., 2005) surface applied calcium phosphate stimulated emergence of obnoxious weeds even in flooded rice. However, some studies revealed that no special effects of varying N levels were observed on weed populations under observation (Satorre and Snaydon, 1992; Gonzalez, 1998). In another study, *Palmer amaranth* was reported as highly responsive to increased fertilization rate (Ruf-Pachta et al., 2013). Toler et al. (2004) studied that normally weeds respond positively to the starter fertilizer dose and grow well. In Australia, Myers and Moore (1952) studied response of composition of some winter weeds to NP fertilizers. They noted that weeds respond differently to nutrients, for instance *Cryptostentma calendula L.* and *Medicago denticulata* Wild. were dominant in given population when N alone and P alone were applied respectively, while combined effect of NP increased population of grasses.

FERTILIZER APPLICATION TIME

Application timing of fertilizers also influence many weed species and their distribution patterns (Angonin et al., 1996). Fertilizer should be applied at proper time so that weed infestation and proliferation can be checked to get maximum production

Table 2. Effect of N source variation on weed abundance

Weed species	Weed abundance (%)			
	Whole NPK through inorganic source	Full organic N in NPK dose	Half organic N in NPK dose	No organic N in NPK dose
Capsella bursa-pastoris	31.7	18.8	12.5	25.5
Cephalanoplos segtum	0.3	1.2	0.4	0.6
Calystegia hederacea	0.0	0.2	0.1	0.0
Descurainia sophia	2.8	2.4	1.9	5.5
Galium aparine	0.0	3.1	0.0	0.0
Polygonum amphibium	0.0	2.5	0.0	0.0
Silene conoidea	0.0	0.0	1.1	2.8
Vicia cracca	0.0	2.5	0.0	1.0

Source: Yin et al. (2005)

from crop plants by optimize use of nutrients (Moody, 1977). Furthermore, varying fertilizer application timing may reduce nutrient uptake by weeds as improper time might develop stressful environment to weeds irrespective to crop stand establishment (Ahmad and Moody, 1981). Timing of fertilizer application also affects weed biomass attainment and density increment, for instance Blackshaw et al. (2004) reported growth of four weeds (wild oat, green foxtail, wild mustard and common lambsquarters) in wheat was lower during fall applied N as compared to spring applied N. However, nitrogen application method generally had more reliable and significant effects than application timing on weed growth (Blackshaw, 2005). This was supported by Evans et al. (2003), who observed that time of fertilizer application can start or end the competition, while if fertilizer is applied at early crop growth season; weeds may be control to substantial level.

FERTILIZER APPLICATION METHODS

Information on fertilizer placement methods might aid in developing improved weed management programmes. Different fertilizer application methods have different effect on weeds establishment (Table 3). Broadcasting of fertilizers is an easy option but the FUE is less and losses of nitrogen through volatilization, denitrification and surface runoff are more. Surface broadcasting of fertilizers cause intense acidification that may decrease the persistence of many herbicides and may stimulate some others that means this method affect weed populations by influencing the herbicides activity (Moody, 1981; Mahler, 2001). Fertilizer availability near soil surface determines weeds emergence, as reported by Guza et al. (2008), significant reduction in weed emergence was observed when nitrogen availability was reduced

Table 3. Effect of N application method on weed biomass

Weed species	Year	Increase in shoot biomass compared with unfertilized control (%)		
		Broadcasting	Banding	Injection
Wild oat	1	48.3	59.4	30.4
	2	73.4	72.5	50.0
	3	85.5	79.6	51.0
	4	81.0	71.8	74.4
Green foxtail	1	47.5	24.5	23.2
	2	53.0	34.4	-
	3	47.0	25.0	-
	4	75.0	50.0	0.0

Source: Blackshaw et al. (2004)

near soil surface, in addition to increased time span for timely herbicide applications. In another study, it is noted that weeds performance decreased from 25 to 63% via point injection method of N rather than broadcast (Blackshaw et al., 2004). Several studies have revealed that subsurface banding of nitrogen and phosphorous is the best suitable option (Mahler, 2001; Blackshaw and Molner, 2009). Reduction in nitrogen uptake by weeds under subsurface banding treatment was reported as compared to broadcasting (Blackshaw, 2005). Banding of fertilizers has given much better weed control as compared to broadcasting in many agronomic crops (Everaarts, 1992). Reduction in N uptake and attainment of weed biomass was observed due to subsurface band placement of N than broadcasted N (Blackshaw, 2005). The dibbling of fertilizers especially in nursery plants is one of the most effective methods. Different species of plants and weeds showed different responses under this treatment (Meadows and Fuller, 1983; 1984). It reduced the labor of hand weeding; reduce competition and reduction in herbicide use for nursery crops. The effect was more on the small seeded weeds like prostrate spurge more by imposing nutrient deficiencies that limit germination and growth (Yeager et al., 1997).

ORGANIC FERTILIZERS AND WEED MANAGEMENT

Organic manures are good option for sustainable land use and crop productivity. Weed density and dry weight were more in fields where green farm yard and poultry manures were applied while there was less weed infestation in fields having inorganic fertilizers (Table 4). Some studies elucidated that composted manure may reduce weed infestation by altering soil physical and chemical properties, including water holding capacity, aggregate stability, bulk density and soil temperature (Singer et al., 2004), reduces weed seed bank in soil (Menalled et al., 2009). Furthermore, compost limits weed growth by releasing phytotoxic sub-

Table 4. Effect of combinations of organic fertilizers on weed attributes

Organic fertilizers	Weed density increase over control (%)	Weed fresh wt. increase over control (%)	Weed dry wt. increase over control (%)	Reference
GM+FYM+PL	20.4	16.2	31.0	Hammad et al. (2010)
GM+FYM+PM	32.6	47.2	46.5	
GM+PL+PM	22.2	26.6	34.6	
GM+PL+SS	11.0	16.4	23.5	
GM+PM+SS	12.7	19.1	25.3	

Control=Inorganic NPK, GM=Green manure, FYM=Farmyard manure, PL=Poultry liter, PM=Press mud, SS=Sewage sludge.

stances in immediate environment of weed seeds (Ozores-Hampton et al., 1999), as well reduces weed seed bank and competitive ability. Some experiments revealed that application of compost may increase plant height, biomass and seed production of some weeds (Liebman et al., 2004), while some demonstrated (Menalled et al., 2009) significant reduction in weed seedling emergence under green house conditions. Blackshaw (2005) studied that fresh manures and compost release nitrogen slowly that benefits the weeds more than crop plant, therefore more weeds are present in fields where manures and compost are applied. Seed bank of weeds was highest in fresh manures followed by broadcasted nitrogen fertilizer and then banded nitrogen fertilizers. However, as contradicted by De Cauwer et al. (2010) effect of application of various organic and mineral fertilizers of nitrogen was annotated for 12 years on development of weed seed bank. They reported that, mineral N fertilization has significant effect on total weed seed density, however no response was observed with organic fertilizer. Maintenance of crop residues or addition of nitrogen influences the weed seed mortality. That may be due to indirect action, alteration in seed germination patterns and seed fate (more germination, less mortality) or by direct stimulatory or inhibitory action of microbial predators of weed seeds (Davis, 2007). Conservation tillage provides different environment for weed germination, emergence, growth and competition by altering physical and chemical properties of soil. So, variation in fertilizer doses, application methods and types are needed in accordance with weed responses in such systems. In future, fertilizer-weed interactions in different tillage systems should be focused for scientific experimentation to explore specific weed responses, weed-crop competition periods and adaptations to devise new precise and pragmatic weed management tools for better crop productions, food security and food safety.

CONCLUSION

Weeds cause huge losses in crop production and threaten the global food security. As world agriculture is shifting from conventional intensive practices towards conservation approaches, it is necessary to reduce the fertilizer use and evaluate the effect of different levels on weed dynamics. Conservation tillage provides different environment for weed germination, emergence, growth and competition by altering physical and chemical properties of soil. So, variation in fertilizer doses, application methods, and types are needed in accordance with weed responses in such systems. In future, fertilizer-weed interactions in different tillage systems should be focused for scientific experimentation to explore specific weed responses, weed-crop competition periods and adaptations to devise new precise and pragmatic weed management tools for better crop productions, food security and food safety.

LITERATURE CITED

Ahmad, N.U. and K. Moody. 1981. Effect of time of nitrogen application on weed growth and yield of dry-seeded rice. Int. Rice Res. News 6(2):12-13.

Alkamper, J. and D.V. Long. 1978. Interaction between fertilizer use and weed population. In: Troiseme symposium sur le desherbage des cultures tropicales. Dakar, 1. p. 188-193.

Angonin, C., J.P. Caussanel, and J.M. Meynard. 1996. Competition between winter wheat and *Veronica hederifolia*: Influence of weed density and the amount and timing of nitrogen application. Weed Res. 36: 175-187.

Barberi, P., N. Silvestri, and E. Bonari. 1997. Weed communities of winter wheat as influenced by input level and rotation. Weed Res. 37: 301-313.

Blackshaw, R.E. 2005. Nitrogen fertilizer, manure and compost effects on weed growth and competition with spring weed. Agron. J. 97: 1612-1621.

Blackshaw, R.E. and L.J. Molnar. 2009. Phosphorus fertilizer application method affects weed growth and competition with wheat. Weed Sci. 57(3): 311-318.

Blackshaw, R.E., and R.N. Brandt. 2008. Nitrogen fertilizer rate effects on weed competitiveness is species dependent. Weed Sci. 56(3): 743-747.

Blackshaw, R.E., L.J. Molnar, and H.H. Janzen. 2004. Nitrogen fertilizer timing and application method affect weed growth and competition with spring wheat. Weed Sci. 52: 614-622.

Carpenter-Boggs, L., P.D. Stahl, M.J. Lindstrom, and T.E. Schumacher. 2003. Soil microbial properties under permanent grass, conventional tillage, and no-till management in South Dakota. Soil Till. Res. 71: 15-23.

Cathcart, R.J. and C.J. Swanton. 2003. Nitrogen management will influence threshold values of green foxtail (*Setaria viridis*) in corn. Weed Sci. 51: 975-986.

Davis, A.S. 2007. Nitrogen fertilizer and crop residue effects on seed mortality & germination of eight annual weed species. Weed Sci. 55: 123-128.

De Cauwer, B., K. Van Den Berge, M. Cougnon, R. Bulcke, and D. Reheul. 2010. Weed seed bank responses to 12 years of applications of composts, animal slurries or mineral fertilizers. Weed Res. 50(5): 425-435.

DiTomaso, J.M. 1995. Approaches for improving crop competitiveness through the manipulation of fertilization strategies. Weed Sci. 43: 491-497.

Evans, S.P., S.Z. Knezevic, C. Shapiro, and J.L. Lindquist. 2003. Nitrogen level affects critical period for weed control in corn. Weed Sci. 51: 408-417.

Everaarts, A.P. 1992. Response of weeds to the method of fertilizer application on low-fertility acid soils in Suriname. Weed Res. 32: 391-397.

Freyman, S., C.G. Kowalenko, and J.W. Hall. 1989. Effect of nitrogen, phosphorus and potassium on weed emergence and subsequent weed communities in south coastal British Columbia. Can. J. Plant Sci. 69(3): 1001-1010.

Gonzalez, P.R. 1998. Competition between barley and *Lolium rigidum* for nitrate. Weed Res. 38: 453-460.

Guza, A.E., K.A. Renner, C. Laboski, and A.S. Davis. 2008. Effect of early spring fertilizer nitrogen on weed emergence and growth.

Weed Sci. 56: 714-721.

Hammad, H.M., A. Khaliq, A. Ahmad, M. Aslam, T. Khaliq, S.A. Wajid, A. Hussain, M. Usman, W. Naseem, W. Farhad, and R. Sultana. 2010. Influence of organic manures on weed dynamics and wheat productivity under low rainfed areas. Crop & Environ. 1(1): 13-17.

Hobbs, P.R., and R.K. Gupta. 2004. Problems and challenges of no-till farming for the rice-wheat systems of the Indo-Gangetic Plains in South Asia. In: Lal., R. P. Hobbs, N. Uphoff, and D.O. Hansen. (eds.). Sustainable Agriculture and the Rice-Wheat System. Columbus, Ohio, and New York, USA: Ohio State University and Marcel Dekker, Inc. p.101-119.

Liebman, M., F.D. Menalled, D.D. Buhler, T.L. Richard, D.N. Sundberg, C.A. Cambardella, and K.A. Kohler. 2004. Impacts of composted swine manure on weed and corn nutrient uptake, growth, and seed production. Weed Sci. 52: 365-375.

Lindsey, L.E., D.O. Warncke, K. Steinke, and J.E. Wesley. 2013. Fertilizer and population affect nitrogen assimilation of Common Lambsquarters (*Chenopodium album*) and Redroot Pigweed (*Amaranthus retroflexus*). Weed Sci. 61(1): 131-135.

Mahler, R.L. 2001. Fertilizer placement Cooperative Extension System, Idaho Agricultural Experi-ment Station, College of Agriculture University of Idaho, Moscow.

Major, J., C. Steiner, A. Ditommaso, N.P. Falcão, and J. Lehmann. 2005. Weed composition and cover after three years of soil fertility management in the central Brazilian Amazon: Compost, fertilizer, manure and charcoal applications. Weed Biol. Manage. 5(2): 69-76.

Meadows, W.A. and D.L. Fuller. 1983. Relative effectiveness of dibble applied vs. incorporated Osmocote for container grown woody ornamentals. Proc. South. Nursery Res. Conf. 28: 63-66.

Meadows, W.A. and D.L. Fuller. 1984. Plant quality and leachate effluent as affected by rate and placement of Osmocote and SREF on container grown woody ornamentals. Proc. South. Nursery Res. Conf. 29: 75-79.

Menalled, F.D., D.D. Buhler, and M. Liebman. 2009. Composted swine manure effects on germination and early growth of crop and weed species under greenhouse conditions. Weed Technol.19(4):784-789.

Mesbah, A.O. and S.D. Miller. 1999. Fertilizer placement affects jointed goatgrass (*Aegilops cylindrica*) competition in winter wheat (*Triticum aestivum L.*). Weed Technol. 13: 374-377.

Mohammaddoust-e-Chamanadad, H.R., A.M. Tulikor, and M.A. Baghestani. 2006. The effect of long term fertilizer application and crop rotation on the infestation of fields by weeds. Pakistan. J. Weed. Sci. Res. 12(3): 221-234.

Moody, K. 1977. Weed control in sequential cropping in rainfed lowland rice growing areas in tropical Asia. Paper presented at the Workshop on Weed Control in Small Scale Farms at 6th Asian-Pacific Weed Science Society Conference, July 11-17. Jakarta, Indonesia.

Moody, K. 1981. Weed fertilizer interactions in rice. IRRI research paper series number. 68: 1-36.

Myers, L.F., and R.M. Moore. 1952. The effects of fertilizers on a winter weed population. J. Aust. Inst. Agric. Sci. 18: 152-155.

Ozores-Hampton, M., P.J. Stoffella, T.A. Bewick, D.J. Cantliffe, and T.A. Obreza. 1999. Effect of age of composted MSW and biosolids on weed seed germination. Compost Sci. Util. 7: 51-57.

Ruf-Pachta, E.K., D.M. Rule, and J.A. Dille. 2013. Corn and Palmer amaranth (*Amaranthus palmeri*) interactions with nitrogen in dryland and irrigated environments. Weed Sci. 61(2): 249-258.

Satorre, E.H., and R.W. Snaydon. 1992. A comparison of root and shoot competition between spring cereals and *Avena fatua L.* Weed Res. 32: 45-55.

Singer, J.W., K.A. Kohler, M. Liebman, T.L. Richard, C.A. Cambardella, and D.D. Buhler. 2004. Tillage and compost affect yield of corn, soybean, and wheat and soil fertility. Agron. J. 96: 531-537.

Sweeney, A.E., K.A. Renner, C. Laboski, and A. Davis. 2008. Effect of fertilizer nitrogen on weed emergence and growth. Weed Sci. 56: 714-721.

Toler, J.E., E.C. Murdock, and J.J. Camberato. 2004. Starter fertilizer effects on cotton development and weed interference. J. Cott. Sci. 8: 33-41.

Weaver, S.E., M.J. Kropff, and R.M.W. Groeneveld. 1992. Use of ecophysiological models for crop-weed interference: the critical period of weed interference. Weed Sci. 40: 302-307.

Yeager, T.H., C.H. Gilliam, T.E. Bilderback, D.C. Fare, A.X. Niemiera, and K.M. Tilt. 1997. Best Management Practices Guide for Producing Container-Grown Plants. Southern Nursery Assoc., Marietta, GA.

Yin, L., Z. Cai, and W. Zhong. 2005. Changes in weed composition of winter wheat crops due to long-term fertilization. Agric. Ecosyst. Environ. 107: 181-186.