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Weeds associated with tillage, mulching and Nitrogen in wheat and their effect on yield: a review

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Abstract: ***Weeds play an important role in the production systems. They compete with crops for water, nutrients, air and light thereby resulting poor crop growth. Many narrow leaved, broad leaved and grassy weeds are associated with wheat, which ultimately reduce the grain yield. Weeds are the major constraints to wheat cultivation in many regions of South Asia. It is reported that more than 90 species of weeds infesting this crop in Indian sub-continent and direct yields loss due to mixed weed flora ranges from 20 to 40% depending on weed species. In Nepal, it is estimated that weeds can reduce wheat yield up to 50%, sometimes even higher depending upon the severity and species of weeds. Several studies showed that straw mulch minimized both grassy and broadleaf weeds up to 80% in wheat. Tillage is another important factor in weed management program. Zero tillage or surface seeding technology is gaining popularity in wheat cultivation as it has not only reduced the incidence of most problematic weeds Phalaris minor Retz. and Chenopodium album L. but also improved the input-use efficiency), improved soil condition due to decomposition of crop residues in situ, increase in infiltration rate, reduced cost of seed bed preparation and early sowing of wheat in rice-wheat system.. It is reported minimum weed dry weight with the use of lower dose of nitrogen and it significantly increased with higher dose of nitrogen.***

Keywords: Weed, Tillage, Mulch, Nitrogen.

1. Introduction

In Nepal, wheat is the third most important cereal crop in acreage and production after rice and maize and therefore plays an important role in national food security. More than 84% of wheat areas are after rice. Rice-wheat, a most prominent cropping system in Nepal occupies 37% of the rice and 85% of wheat area of the country (Tripathi et al., 2003). Though, wheat is one of the major cereal crops in Nepal having average yield of 2.41 t ha^{-1} (MOAC, 2012) which is very low in comparison to neighbouring countries. Wheat yield under rice-wheat system is low due to various problems. The major reasons for low productivity of wheat are delay sowing, nutrient deficiencies and weed problems. Many narrow leaved, broad leaved and grassy weeds are associated with wheat, which ultimately reduce the grain yield.

Many scientists from South Asia reported weed as the major constraints to wheat cultivation. Rao (2000) reported more than 90 weed species infesting wheat crop in Indian sub-continent. Likewise, Nayyar et al. (1994) reported weed infestation as the main cause of yield reduction of wheat up to 25-30% in Pakistan. Begum et al. (2003) reported 73 species of weed infesting wheat crop in Bangladesh. Rao (2000) reported 20-40% yield loss in wheat due to weeds in India. Likewise, Pandey et al. (2006) observed an average of 309 weeds m^{-2} which reduced 29% grain yield of wheat in India. In Nepal also, reduction of wheat yield up to 50% was reported by Ranjit (2002). In case of Chitwan area of Nepal, Dangol and Chaudhary (1993) reported 30 weed species of wheat and Ranjit et al. (2006) reported broadleaf weeds as the major problem.

Weeds that grow with crop deplete considerable amount of nutrients and soil moisture thereby resulting poor crop growth. Several studies showed that mulching could minimize both grassy and broadleaf weeds in wheat. Various mulching materials are reported for example organic and synthetic mulch to be effective in suppressing weed growth and conserving soil moisture. Organic mulch includes the straw, hay, dry sugarcane leaves, FYM, rice hulls, saw dust and bark dust while synthetic mulch includes black paper or polythene film which provides stronger mechanical barriers to all kinds of germinating weeds. These synthetic mulches due to their higher cost are limited to only certain high value vegetables and ornamentals (Gupta, 2002). But organic mulches are cheap and easily available, so it can be used in wheat to suppress weeds. In addition it has beneficial effects like soil conservation, moderation of temperature, reduction in salinity and improvement of soil structure. Likewise, Rahman et al. (2005) also reported rice straw mulch to be effective on conserving initial soil moisture, and reducing weed growth, which ultimately improved the grain yield of wheat. Similarly, Verma and Acharya (1996) reported that rice straw mulch to be more effective in increasing the nitrogen use efficiency (NUE) by suppressing weed growth and decreasing the nitrogen loss through volatilization by lowering the soil pH.

Tillage is another important factor in weed management program. Different tillage practices significantly influenced the weed population. Zero tillage or surface seeding technology is gaining popularity in wheat cultivation, as it has not only reduced the incidence of most problematic weeds Phalaris minor Retz. and Chenopodium album L. but also improved the input-use efficiency (Mishra et al., 2005), improved soil condition due to decomposition of crop residues in situ, increase in infiltration rate, reduced cost of seed bed preparation and early sowing of wheat in rice-wheat system. Tillage system also influences the vertical distribution of weed seeds in soil layer and weed diversity. No-till cropping system leaves most of weed seeds in top 1.0 cm of the soil profile (Cardina et al., 1991), while in deep tillage, significant reduction of weed population was observed due to the inversion of soil with mould board plough which resulted in deeper placement of most of the weed seeds which could not emerge out (Chahal et al., 2003).

Uninterrupted nutrient supply during the growth period of crop is pivotal to realize full yield potential of a crop. Weeds, being a serious negative factor in crop production, are responsible for marked losses of crop yield. Angonin et al. (1996) suggested that nitrogen dose should be adjusted at a favorable time in order to enhance the yield components not affected by the weed. They also reported that late application of nitrogen increased the grain weight and the effect of weeds on wheat yield loss was lowest but maximal yield loss was achieved with a single application of nitrogen at tillering stage. So, split application of nitrogen at least 10 days after seeding and 20 days after seeding in full dose greatly influence yield and yield attributes of wheat.

2. Material and Methods

This paper was prepared on the basis of review from different printed materials, books and research papers.

3. Results and Discussion

3.1 Weed flora of wheat

Many grassy and broadleaf weeds are associated with wheat, the occurrence of which may depend upon so many factors such as location, soil fertility, management etc. In South Asia region, for example Begum et al. (2003) reported 73 weed species in wheat crop at Mymensingh region of Bangladesh. Among them, Gnaphalium affine D. Don (33.5%), Chenopodium album (23.3%), Polygonum plebeium R. Br. (15.2%), Digitaria sanguinalis (L.) Scop. (14.8%) and Cynodon dactylon (L.) Pers. (13.6%) had higher relative abundance value as compared to other weeds. Similarly, Aslam et al. (1989) stated that Phalaris minor, Chenopodium album and Rumex acetosella L. were the major problem weeds of wheat in Pakistan.

Hobbs (1990) reported P. minor, A. fatua, Lathyrus aphaca L. and C. album as the major weeds of wheat in India. Similarly, Dwivedi et al. (1996) recorded P. minor, C. album, Anagalis arvensis L., C. dactylon, A. fatua and Vicia sativa L. as the dominant weed species in northern hill region of Chhattisgarh, Madhya Pradesh, India. Nanda and Patro (1996) reported 20 weed species associated with wheat crop at Orissa, India. Pandey et al. (1997) reported different types of monocot and dicot weeds infesting wheat crop at Bihar, India. Among broad leaved weeds, C. album, Fumaria parviflora Lam., Trigonella polycerata, Oxalis corniculata L., Melilotus indica (L.), Convolvulus arvensis L., Spergula arvensis, Lippia nodiflora (L.) and Nicotiana plumbaginifolia Viv. and in case of grassy weeds P. minor, A. fatua and C. dactylon and among the sedges Cyperus rotundus L. predominantly infested the crop field. Singh et al. (1997) reported total weed population varied from 4.30 to 60.04 weeds m^{-2} at harvesting stage of wheat at Jabalpur, India.

A survey conducted by Chaudhary and Shrestha (1981) reported a large number of weeds at Kirtipur area of Nepal in association with wheat crops and the major weeds reported were Cannabis sativa L., C. album, P. minor and Vicia spp. The common weeds in the experimental field of Khumaltar, Nepal during 2001/02 were P. minor, Alopecuros sp., C. album, Stellaria media (L.), Polygonum hydropiper L., Bothiospermum, Rumex sp., Senecio vulgaris and reported that C. album as the dominant weed at all the wheat field having numbers ranged from 500 to 900 per $0.5m^2$ area (NARC, 2002). Also, another experiment during 2004/05 reported different types of weeds like P. minor, Alopecuros aequalis Sobol., Stellaria media, C. album, Gnaphalium affenes D. Don, Soliva anthemifolia (Juss.) R. B., A. arvensis, Vicia spp. etc. in wheat field. Among them A. aequalis, C. album, S. media, S. anthmifolia and P. minor were reported commonly in wheat (NARC, 2006). Joshi (1996) recorded 64 weeds species of wheat from Kabhre district of Nepal and found 9 weed species like P. hydropiper, A. aequalis, C. album, Polypogon fugax Nees ex Steudel, P. minor, P. plebeium, A. fatua, S. anthemifolia and Stellaria uliginosa as dominant in wheat. Ranjit et al. (2006) reported broadleaf weeds like C. album, Fumaria sp. and Ageratum sp. as the major weed flora in Chitwan area of Nepal. Thirty weed species belonging to 16 families and 25 genera were reported in wheat field at Rampur, Chitwan, Nepal (Dangol and Chaudhary, 1993). Among them, 28 were annual and 2 perennial. C. dactylon, D. adscendens, A. houstonianum and C. album were as found major weed species at IAAS, Rampur, Nepal and adjoining areas were reported by Dangol et al. (1993).

3.2 Yield loss in wheat due to weeds

Weeds play an important role in the production systems. They compete with crops for water, nutrients, air and light. Weeds are the major constraints to wheat cultivation in many regions of South Asia. More than 90 species of weeds infest this crop in Indian sub-continent and direct yields loss due to mixed weed flora ranges from 20 to 40%, depending on weed species (Rao, 2000).

Nayyar et al. (1994) reported weed infestation as the main cause of yield reduction of wheat up to 25-30% in Pakistan. There are also several different reports of yield loss of wheat due to weeds in India were reported such as 10-50% (Walia et al., 1990), 34.3% (Tiwari and Parihar, 1993) and 10-80% (Khera et al., 1995). Similarly, 28.9-52.2% (Pandey et al., 1998) and 29% (Pandey et al., 2006) reduction in wheat yield due to season long weed competition at mid hills of North West Himalayan region of India were reported. Pandey and Verma (2002) reported significant decrease in plant height of wheat, productive tillers m^{-1} row length, grains $panicle^{-1}$ and 1000 grain weight and lowered crop yield by 27.2% due to weed competition. Dwivedi et al. (1996) reported 30 to 50% yield reduction in wheat due to heavy infestation of broad-spectrum weed flora in the northern hill region of Chhattisgarh, Madhya Pradesh, India. Similarly, Chopra et al. (1999) reported that uncontrolled weeds caused 30.68% grain yield loss in wheat. Mondol et al. (2007) from Bangladesh investigated the effect of C. album competition on growth and yield of wheat and reported that the highest reduction of wheat yield under weedy check treatment were the result of reduction of total tillers per plant by 31%, reduction of effective tillers per plant by 43.34%, reduction of grains per spike by 14.57% and reduction of total dry weight of wheat by 34.5%.

It is estimated that weeds can reduce wheat yield up to 50% in Nepal, sometimes even higher depending upon the severity and species of weeds (Ranjit, 2002). Similarly, Harrington et al. (1992) reported productivity loss of wheat due to weeds in Kabhre district of Nepal to be 8-37% with annual frequency of occurrence as much as 100% and annual regional productivity loss as much as 6-10%. Similarly, 33% yield loss in wheat due to weeds was reported by Joshi (1996) at Sipaghat, Kabhre district of Nepal.

3.3 Tillage in relation to weed and crop yield

Yadav et al. (2005) from India reported that the grain yield and number of effective tillers m^{-2} increased by 7.7% and 6.6% respectively with zero tillage over conventional tillage due to the better establishment of plants as a result of less weed competition. Similarly, significant reduction in dry weight of weeds was observed with zero tillage over conventional tillage. Mishra et al. (2005) observed that deep tillage significantly reduced the population of weeds compared to zero tillage system due to the deeper placement of most of the weed seeds which could not emerge out. Zero tillage or surface seeding reduced the infestation of P. minor and C. album but increased the problem of wild oat. But, Gupta (2002) reported that deep and frequent tillage bring more of dormant weed seeds and rhizomes to the soil surface and also preserve the new ones deep inside the soil for the future, which are undesirable.

Significant effect on wheat production was observed due to different tillage practices and weed management practices. Ranjit (1998) reported maximum number of S. anthmifolia, A. arvensis and Alopecuros sp. in zero tillage but higher number of C. album, P. minor, Polygonum sp., and Cannabis sativa L. in normal tillage. Dry weed weight was less in reduced and normal tillage as compared to zero tillage in both the years. The highest yield was recorded in normal tillage however; the reduced tillage and zero tillage were at par. According to Ranjit (2000), the grassy weed was lowest in zero tillage but at par with normal tillage. The highest broadleaf weeds were recorded in normal tillage with lowest in reduced tillage (Chinese seed drill). Broad leaf and grassy weeds removed more NPK in zero tillage and reduced yield, respectively. Ranjit and Suwanketnikom (2003) reported no specific weed species associated with the tillage systems and stated both the tillage systems have same type of weed species but with different intensities. There were more narrow leaves than broadleaf weeds in both tillage systems. The most common narrow leaf weed species were A. aequalis and P. minor, while broadleaf dicot was C. album, C. didymus, R. crispus, S. media and S. anthemifolia. The population of A. aequalis, P. minor, R. crispus and S. media was higher in conventional tillage than in minimum tillage. The total population of narrow leaf weeds was higher in conventional tillage than in minimum tillage at 4 and 8 weeks after seeding of wheat.

Arshad et al. (1994) reported that higher yields were obtained from reduced tillage than conventional tillage or zero tillage. Polygonum convolvulus L. was more abundant under conventional tillage but S. vulgaris, Taraxacum officinale Wigg., Galeopsis tetrahit L., Equisetum arvense and Polygonum scabrum Moench. tended to have higher populations under the zero tillage system. The reduced system is also economical and environmentally desirable owing to lower tillage and herbicide requirements. Streit et al. (2002) reported less density of weeds was associated with no-tillage than in minimum and conventional tillage system and also reported perennial weeds in no-tillage while annual broad-leaved species associated with minimum and conventional tillage plot. Singh et al. (2001) reported more weed emergence in conventional tillage (146 m^{-2}) and reduced tillage (141 m^{-2}) than in zero tillage system (103 m^{-2}) at 30 days stage and the highest average grain (3872 kg ha^{-1}) and biological yield (10536 kg ha^{-1}) was obtained under zero tillage weed-free situation which was at par with conventional tillage. Malik et al. (2000) reported that the density and dry weight of P. minor remained significantly higher under conventional method of wheat sowing compared to zero-tillage throughout the crop season. Yadav et al. (2007) reported that conventional tillage reduced weed infestation (weed density and dry weight) significantly and caused a remarkable reduction in weed density (50%) and weed dry weight (55.1%) as compared to zero tillage. Singh et al. (1998) also reported less weed infestation (weed density and dry weight) with conventional tillage over zero tillage. Jain et al. (2007) reported that the tillage practices did not influence the intensity of weeds; however weed density and dry weight was lower in conventional tillage than zero tillage non-significantly.

3.4 Mulching in relation to weed and crop yield

Kumar et al. (1995) reported straw mulch either applied in flat beds or ridge and furrow reduced the weed density and dry weight m^{-2} significantly compared with flat bed and ridge and furrow without mulch due to its smothering effect on weeds. The smothering effect of mulch on weed was also reported by Yadav et al. (2007). Rahman et al. (2005) reported rice straw mulching had a significant effect on conserving initial soil moisture, promoting root development and reducing weed growth, which ultimately improved the grain yield of no-till wheat. Ranjit and Suwanketnikom (2003) reported that straw mulch suppressed narrow leaf weeds up to 23% and broadleaf weeds up to 36% compared to unweeded control at 4 weeks after sowing of wheat. Similarly, Verma and Acharya (1996) reported that rice straw mulch was more effective in suppressing weeds in wheat and the maximum root growth and water uptake were obtained at 120 kg nitrogen per hectare and in mulched treatments. Nimje (1994) found that mulching @ 5 t ha^{-1} was effective in controlling weeds (23%) and increased grain yield (9.3%) in soybean. Also, Maharjan and Kanwar (1993) reported that mulching with pine (Pinus sp.) @ 10 t ha^{-1} just after sowing increased the grain yield of wheat by 16% compared with no mulching.

Ranjit (2002) reported the effect of rice straw mulching (4 t ha^{-1}) on wheat plants during the sixth week of planting. During this stage, wheat plants were dark green in all the mulched treatments than no mulch. Both grassy and broad leaf weeds were suppressed up to 80% by the straw mulch and thus higher yield of wheat was obtained. Tillers of wheat were also more in mulch compared to no mulch treatments. Weeds like C. album, Rumex sp., P. hydropiper, S. media, C. sativa and S. vulgaris were among the broadleaf weeds and P. minor and Alopecuros sp. were among the narrow leaf weeds in the experimental field. Among them, P. minor, Alopecuros sp. and C. album were the dominant weeds. Similarly, NARC (2002) also reported the number of C. album ranged from 500 to 900 per 0.5 m^2 in wheat field but with rice straw mulch, this weed was suppressed from 200 to 399 per 0.5m^2. The effect of mulching was noted on the wheat plants during the sixth week of planting. The wheat plants were dark green in all the treatments with mulch compared to no mulch. There were also more number of tillers m^{-2} and grain yield in mulched plot. Pandey et al. (1997) reported that weed count and weed biomass decreased with increasing levels of mulching (50 q ha^{-1}) than no mulching. NARC (2000) reported that when straw mulch was applied at the rate of 4 t ha^{-1}, weedy check with mulch treatment suppressed the weeds about 50 % compared to without mulch. Yadav et al. (2007) reported that mulch reduced the weed density and dry weight m^{-2} by 31% and 46.9%, respectively over no mulch and also reported significantly more grain and straw yield than non-mulched crop.

3.5 Nitrogen in relation to weed and crop yield

Yadav et al. (2005) reported dry weight of weeds were minimum with 120 kg N ha^{-1} and it increased significantly up to 180 kg N ha^{-1} in wheat field. Nanda and Patro (1996) reported that application of NPK (100:50:50 kg ha^{-1}) recorded significantly lower weed population when examined in isolation and in combination with narrower row spacing of 15 cm. Root and shoot growth of many agricultural weeds was more responsive to higher levels of nitrogen than that of crops. Indiscriminate nitrogen fertilizer use has the potential to benefit weeds at the expense of crops (Blackshaw et al., 2003). Late application of nitrogen increased the grain weight and the effect of Veronica hederifolia on wheat yield loss was lowest. Maximal yield loss was achieved with a single application of nitrogen at tillering stage and suggested that nitrogen dose should be adjusted at a favorable time in order to enhance the establishment of yield components not affected by the weed (Angonin et al., 1996). Panwar et al. (2000) stated that nitrogen had a significant influence on population of A. ludoviciana and Melilotus indica L.. Application of 40 and 80 kg N ha^{-1} increased the population of A. ludoviciana by 54.5 and 65% respectively over no nitrogen indicating the fact that nitrogen fertilization favored the build up of wild oat population. The dry weight of grass weeds which constituted mainly wild oats increased with increase in applied nitrogen both at 60 and 120 DAS. Grass weeds accumulated 183.9 and 275.9% additional dry matter when crop was supplied with 40 and 80 kg N ha^{-1} respectively over control. Pandey et al. (1997) reported that weed count and weed dry biomass increased with increasing levels of nitrogen and recorded significantly higher values with 100 kg N ha^{-1} at all stages. Jornsgard et al. (1996) reported that an increased level of applied nitrogen did not enhance weed germination, tended to decrease the total weed biomass of individual weed species in both wheat and barley but Yadav et al. (2005) stated the dry weight of weeds were minimum with 120 kg nitrogen and increased significantly up to180 kg N ha^{-1}. Also, under zero tillage, yield was improved significantly by higher N levels due to less lodging, better utilization of water and other favorable factors.

4. Conclusions

Weeds are the major constraints to wheat cultivation in many regions of South Asia. They absorb nutrients and moisture faster and smother the crop plants leading to reduced yield. They are also harmful in three main aspects: they lower yield of crop plants through competition, increases agricultural costs and reduce quality of produce. It is reported that more than 90 species of weeds infesting this crop in Indian sub-continent and direct yields loss due to mixed weed flora ranges from 20 to 40% depending on weed species. In case of Nepal, it is estimated that weeds can reduce wheat yield up to 50%, sometimes even higher depending upon the severity and species of weeds. Tillage is another important factor in weed management program. Zero tillage or surface seeding technology is gaining popularity in wheat cultivation, as it has not only reduced some problematic weeds but also improved the input-use efficiency and reduced cost of seed bed preparation. Several studies showed that mulching minimize both grassy and broadleaf weeds in wheat. Both grassy and broad leaf weeds were suppressed up to 80% by the straw mulch and thus higher yield of wheat was obtained. It is also reported minimum dry weight of weeds with 120 kg N ha^{-1} and it increased significantly up to 180 kg N ha^{-1} in wheat field.

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