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Performance of inorganic and organic inputs in wheat production: A Review

Hardeep Singh Sheoran[1], Harender Singh Dahiya[2], Mohammad Amin Bhat[1] and Shamsher Singh[1]

1. Department of Soil Science, CCS Haryana Agricultural University, Hisar-125004 (Haryana, India)
2. Department of Agronomy, CCS University, Meerut

Email: ***sheoranhardeep2008@gmail.com***

Abstract

Soil fertility is a key element in determining the outcome of all farming systems. In India, Wheat (*Triticum aestivum L.*) is a dominant *rabi* cereal crop of north-western zone of India and it is second most common crop of the country. After the Green revolution increasing cropping intensity, use of modern varieties, cultivation of high biomass potential crops, nutrient leaching and unbalanced fertilizer application with no or little addition of organic manure have resulted in nutrient mining from soil. To stop nutrient mining and use of imbalance of fertilizers, it is not justified to just increase the use of inorganic fertilizers, the organic sources of plant nutrients viz. cow dung, poultry manure, compost, green manure etc. need to be also considered. Organic matter is known as 'storehouse of plant nutrients' and 'life force of a soil'. Organic manures such as vermicompost can be prepared at own fields of farmers and thus reducing the cost of cultivation. Therefore, to achieve improved and sustainable soil fertility and crop yield, balanced and integrated application of chemical and organic fertilizers is a key factor. Maintenance of soil fertility is a prerequisite for long term sustainable agriculture and organic manure can play a vital role in sustaining soil fertility and crop production. Here, this paper describes the role of organic sources in conjugation with fertilizer in wheat production in present day's situation of intensive farming. Secondly, In Haryana, *Phalaris minor* is the major weed which creates problem in wheat cultivation. As hand weeding is costly, time consuming and cumbersome one, the only alternative is to go for chemical weed control. Herbicides are chemical to eliminate weeds. Here this paper aims to collect review on the effect of nitrogen and vermicompost in presence of herbicide on wheat yield.

Key words: Nitrogen, Vermicompost, Herbicide, Soil and Wheat yield

Introduction

Wheat (*Triticum aestivum L.*) is a dominant *rabi* cereal crop of north-western zone of India. India is producing about 92.45 million tons of wheat from an area of 29.64 million hectare with an average productivity of 3119 kg ha^{-1} (Anonymous, 2013). Haryana, which is one of the major wheat growing states, produces 111.17 lac tons of wheat from 24.97 lac hectares area with an average productivity of 4452 kg ha^{-1} (Anonymous, 2013). Nitrogen is an essential constituent of protein which is associated with all the vital processes in plants. Therefore, addition of nitrogen in the form of chemical fertilisers is important in order to get maximum crop production. Balanced use of nitrogen is a key point for higher land profitability and healthy environment. Nitrogen is one of the major essential nutrients applied to the crop for higher vegetative growth, productivity and quality (Iqbal *et al*., 2012). Due to intensive cropping, where food grain production and fertilizer use run parallel, soil is degrading day by day with respect to soil fertility and productivity. This may be attributed to the minimum and extra removal of nutrient resources from the soil strata than they are replenished, so soil is becoming deficient in available nutrients. Since, agriculture becomes more intensive and chemical dependent, therefore soil toxicities and nutrient imbalance threaten sustainable production. So, we have to think about the cheap and easily available alternate source of nutrients, which not only supply the nutrients to the soil but also improve the physico-chemical properties of the soil. Thus, demand for fertilizers can be lowered by supplementing the nutrients through organic manures. In recent years due to unsuitable effect of chemical fertilizers on the soil, using of organic materials serves as a good and suitable source to supply soil food elements. In addition to supply nutrients, organic manures may improve the soil health, physico-chemical properties and biological conditions of the soil. Judicious use of FYM with chemical fertilizers improves soil physical, chemical and biological properties and improves the crop productivity (Sharma *et al.* 2007). Application of organic manures may also improve availability of native nutrients in soil as well as the efficiency of applied fertilizers (Sawrup, 2010). Organic materials, such as green manure (GM), crop residues and animal manure, and their continuous use have a strong influence on soil productivity and N dynamics in the soil–plant system (Schmidt and Merbach 2004). Among different sources of organic manures, vermicompost is most important source and used since long as a nutrients supplement to crop production. Solid waste generation in India is about 115,000 tons per day with a yearly increase of about 5% (Jain *et al*. 2014). The estimated annual increase in per capita waste quantity is about 1.33% per year. The 11th Five Year Plan of India has envisaged an investment of approximately Rs. 2,000 crores for Solid Waste Management (SWM). The large amount of the agro waste generated has created major environmental problems. Vermicomposting is the best biotechnology to reduce the load on the treatment and disposal of biodegradable agro waste. In Haryana, *Phalaris minor* is the major weed which creates problem in wheat cultivation. Besides reduction in yield heavy *P. minor* population causes crop lodging. As hand weeding is costly, time consuming and cumbersome one, the only alternative is to go for chemical weed control. Herbicides are chemical to eliminate weeds. Various post-emergence herbicides are used to control weeds in wheat crop world over such as 2, 4-D, imazamethabenz, fenoxaprop plus MCPA plus thifensulfuron plus tribenuron, bromoxynil plus MCPA, flufenacet, fenoxaprop-p-ethyl, metribuzin and clodinafop propargyl, chlorotoluron + MCPA (Chhokar and Malik, 2002). Arif et al. (2004) evaluated different post-emergence herbicides (2,4-D ester, puma supper 75 EW, Buctril M 40 EC, Buctril M 40 EC + Puma supper and weedy 16 check). They reported that herbicides application affected fresh and dry weed biomass, tillers per m2, spike length, grains per spike, plant height and grain yield. Among herbicidal treatments mixture of Buctril M 40 EC and Puma supper produced maximum plant height, spike length, grains spike-1 and grain yield, whereas weedy check had minimum values for these parameters.

However, little information is available on the chemical nature and distribution of different soil N fractions with the use of different organic and inorganic inputs in the presence of herbicide in rice–wheat cropping system. Keeping in view the significant role of nitrogen in crop production systems, the present review paper was designed to study the effect of nitrogen, vermicompost and herbicides applications on nutrient uptake and wheat yield.

Review of Work Done

The available pertinent literature on "**Evaluation of inorganic and organic inputs in combination with chemical weed control in wheat production: A Review**" has been reviewed under the following heads:

Effect of nitrogen on wheat yield

Ayoub *et al*. (1994) reported the increase in yield and yield parameters of wheat with the increase in successive N levels from 0, 60, 120 and 180 kg N ha^{-1}. Increase in grain yield was from 27 to 81 % at N rates of 120 and 180 kg ha^{-1}, respectively. Geleto *et al*. (1995) reported that grain and biomass yield and most grain yield components increased by increasing N rate. Frederick and Camberato (1995) reported the influence of N rates on yield and yield associated traits of wheat on irrigated fields. They reported significant increase in grain yield with 135 kg N ha^{-1}. Singh *et al*. (1996) reported that the application of N recorded more grain and straw yield of rice and wheat over control. Straw and grain yield of both crops increased up to 90 kg nitrogen per ha^{-1}. Rajender *et al*. (1997) reported that there was a linear rise in grain yield and straw yield with every additive dose of NPK fertilizer up to 120-60-40 kg NPK ha^{-1}.

Singh and Bhan (1998) reported that grain yield of wheat were favorably affected by increased nitrogen levels. Delogu *et al*. (1998) reported influence of different N rates (0, 140, & 210 kg ha^{-1}) on yield and yield related parameters of wheat. Grain yield was maximum at N_{210} (7.5 t ha^{-1}). Kirda *et al*. (2001) reported that highest grain yield ranged from 4.9 - 6.9 t ha^{-1} with 240 kg N ha^{-1}. Wheat benefited least from the fertilizer applied near planting. Lloveras *et al*. (2001) studied impact of five N levels on wheat under irrigated conditions and reported that grain yield of wheat increased with increase in N application up to 300 kg N ha^{-1}, however, maximum spikes per m^2 and maximum grains per spike were produced by 200 kg N ha^{-1}. Fan *et al*. (2005) reported that N fertilizer significantly affected grain yield. N input > 120 kg N ha^{-1} in the wheat season has resulted in luxury uptake of N by the crop. After the wheat harvest, soil N ranged from 66 - 88 kg N ha^{-1} and increased with rising nitrogen rate. Iqtidar *et al*. (2006)

reported that nitrogen levels had significant effect on grain and straw yield of wheat. However, grain yield and biological yield were statistically similar at 150 and 200 kg N ha^{-1}.

Mehndi *et al*. (2007) found that increasing fertilizer levels over control increased the grain and straw yields significantly. Fois *et al*. (2009) reported that N fertilizer enhances grain yield. Ali *et al*. (2011) reported that grain yield was significantly increased by increasing the nitrogen levels over control. Among nitrogen levels, highest grain yield (3.848 tons ha^{-1}) was obtained by an application of 180 kg N ha^{-1}. Tababtabaei and Ranjbar (2012) reported that the highest rate of grain yield for triticale (6.1 t ha^{-1}) was obtained by application of 160 and 90 kg ha^{-1} nitrogen and potassium, respectively. Siddiqui *et al.* (2013) reported that the yield and yield contributing characters of wheat showed positive response with an increase in nitrogen levels up to 160 kg N ha^{-1}. The highest grain yield (3.32 t ha^{-1}) was obtained from 160 kg N ha^{-1}, whereas the lowest (1.51 t ha^{-1}) was recorded from 0 kg N ha^{-1}.

Effect of nitrogen on nutrient uptake in wheat

Singh and Anderson (1978) observed that percentage of nitrogen in the whole plant and plant parts showed increasing trend with increasing nitrogen application but, at harvest, the difference in nitrogen concentration in leaf and grain was significant at 100 and 150 kg N ha^{-1} compared to control. Parkash (1988) found that the increasing levels of nitrogen increased the nitrogen content in both grain and straw significantly upto 120 kg N ha^{-1}. Further increase in nitrogen did not improve the nitrogen content in grains significantly but recorded significant increase in nitrogen content of straw upto 160 kg N ha^{-1}. Gupta *et al*. (1992) reported that uptake of N, P, K in wheat increased with increasing level of nitrogen. Tomar and Singh (1994) observed that increased application of N increased its uptake in wheat.

Kumar *et al.* (1995) observed that increased N application from 0 to 180 kg N ha^{-1} increased the N content in shoot at spike initiation as well as in grain and straw at maturity in wheat. It was also observed that application of N increased its uptake through grain and straw with increased doses of fertilizer N. Nedelciuc *et al*. (1995) reported that a minimum mineral fertilizer rate of 80 kg P_2O_5 ha^{-1} was considered necessary to ensure normal P uptake. Dillon and Brar (1997) indicated that both rice and wheat responded significantly to applied nitrogen and nitrogen uptake was enhanced. Garabet *et al*. (1998) examined wheat yield and N fertilizer uptake for two seasons and found that during both seasons N uptake was greater in fertilized treatments than in unfertilized treatments. Yields were increased by N fertilization, with a greater response to N in 1st year. Most fertilizer N was taken up from tillering to anthesis; then it either stabilized or slightly declined, while soil N contributed further to plant N uptake.

Kibe *et al*. (2006) studied the influence of three N levels (0, 50 and 100 kg N ha^{-1}) on wheat performance. Increase in N application increased N uptake, total biomass and grain yield. Laghari *et al.* (2010) reported that fertilizer application significantly enhanced growth, yield and nutrient uptake of wheat. Application of 120-60-60 NPK kg ha^{-1} recorded maximum grain yield and NPK uptake. Rastgoul *et al.* (2013) reported that the highest N uptake was obtained from 200 kg N ha^{-1} (more than 20%).

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Effect of vermicompost on wheat yield

More (1994) found that with FYM @ 25 t ha^{-1} gave significantly higher yield of wheat over control. Lozek and Fecenko (1998) reported that foliar application of vermisol special (vermicompost extract + mineral nutrients) to winter wheat gave a mean yield of 7.62 t ha^{-1} in combination with 30 kg N ha^{-1}, compared with 7.28 t from nitrogen alone and 6.71 t in unfertilized control. Desai *et al*. (1999) found that maximum growth and grain yield of wheat was obtained with an application of 120 kg N ha^{-1} half through vermicompost and half through urea. Vasanthi and Kumaraswamy (1999) reported that grain yield of wheat were significantly higher in the treatments that received vermicompost from organic materials plus NPK at recommended levels than in treatments that received NPK alone.

Ranwa and Singh (1999) reported that application of vermicompost at the rate of 10 t ha^{-1} remaining at par with 7.5 t ha^{-1} significantly increased the grain and straw yield of wheat over 5 t ha^{-1}. Nehra (2000) reported that application of vermicompost @ 15 t ha^{-1} recorded maximum value for all growth parameters and produce significantly more yield as compared to other organic manures. Bhardwaj *et al*. (2000) reported that wheat cultivars were sown in pots with vermicompost at 5, 10 and 20 % of NPK (Raj 3765 and Raj 3777) and 20% vermicompost produced the highest wheat yield.

Kherdekar *et al*. (2000) reported that yield of mulberry increased significantly with 5 t vermicompost + NPK @ 80:60:60 kg ha^{-1}. Khandal and Bhardwaj (2000) found that application of 20% vermicompost to wheat favoured the production and grain yield as compared to other treatments like control, other organic manures and chemical fertilizers. Patil and Bhilare (2001) reported that application of vermicompost has recorded highest seed yield (39.00 q ha^{-1}) in wheat. Atiyeh *et al*. (2002) reported that vermicomposts contain plant growth-regulating materials, such as plant growth hormones and humic acids, which are probably responsible, at least in part, for the increased germination, growth, and yields of plants in response to vermicompost application or substitution. Thakaral *et al*. (2003) revealed that recommended dose of N and P_2O_5 along with 5 t ha^{-1} of vermicompost produced highest grain yield.

Channabasanagowda *et al*. (2008) reported that application of vermicompost @ 3.8 t ha^{-1} + poultry manure @ 2.45 t ha^{-1} in wheat recorded significantly higher seed yield (3043 kg ha^{-1}), compared to other treatments. Duhan *et al*. (2011) conducted a pot experiment to study the effect of some underutilized manures and urea-N on yield of wheat and found that yield of wheat increased significantly with increasing doses of nitrogen fertilizer alone upto the level of 150 mg N kg^{-1} soil and with organic manures alone upto the level of 50 mg C kg^{-1} soil. Among the organic manures vermicompost showed best results with regards to yield and plant nutrition. Joshi *et al*. (2013) reported that application of VC and recommended dose of NPK recorded the maximum yield. All the growth and yield parameters were found superior with vermicompost treatment over control.

Effect of vermicompost on nutrient uptake in wheat

Singh *et al*. (1981) reported that increase in nitrogen concentration in grain and straw of wheat with FYM application indicated that FYM was a good reservoir of essential plant nutrients including nitrogen and it also enhanced release of native nutrients from the soil. Wang and Qing (1994) reported that in pot trails with wheat, nitrogen in wheat was significantly correlated with parameters of soil mineralization. Rathore *et al.* (1995) found that manuring with 5 t ha^{-1} FYM increased the uptake of NPK by wheat as compared to control. Gupta *et al.* (1996) reported that nitrogen and phosphorus uptake in wheat increased upto 120 and 40 mg N, respectively, with manure application except for FYM application.

Jadhav *et al.* (1997) in apot experiment observed that dry matter production and uptake of the most of major nutrients were highest from 75 kg N ha^{-1} as urea and 25 kg N ha^{-1} as vermicompost.Benbi *et al.* (1998) reported that application of FYM resulted in higher uptake of nutrients in wheat as compared to fertilizer N, P, K alone. Sreenivash *et al*. (2000) reported that N content increased significantly with the increased level of vermicompost. The highest uptake was observed with vermicompost @ 10 t ha^{-1} + NPK through chemical fertilizers. Khokhar and Nepalia (2010) found that among nutrient management treatments, application of 75% RDF + vermicompost @ 1.5 t ha^{-1} and 50% RDF + vermicompost at 3.0 t ha^{-1} resulted in significant increase in NPK uptake in grain and straw over RDF alone.

Davari *et al*. (2012) reported that VC + RR + B was the most productive treatment, while FYM + RR +B was the most economical treatment with respect to increasing net profit. Both of these combinations resulted in improved grain quality and nutrient uptake by grain. Sefidkoohi and Sepanlou (2013) reported that vermicompost (VC) application have positive effects on uptake of phosphorous by shoot and kernel wheat. The results showed that maximum P uptake was observed by the shoot and grain of wheat with the application of 5 consecutive periods of 20 t VC ha^{-1} + 1/2 NPK.

Effect of herbicides on wheat yield

Robison and Fenster (1973) found that the grain yield of one out of five cultivars of winter wheat tested was affected by a typical use of dicamba. Rardon and Fay (1980) observed that application of metribuzin @ 0.38, 0.50 and 0.75 lb acre^{-1} resulted in reduction of yield from 60-90 per cent when applied prior to the development of crown roots, however, the reduction in yield from 5-25 per cent was observed when the number of leaves were more. Griffin (1986) reported that pre and post emergence application of metribuzin at various rates for controlling of different weeds did not show any effect on plant grain weight.

Katyal *et al*. (1998) reported that a 0.75 kg ha^{-1} of IPU applied as pre-emergence and before first irrigation had a distinct depressing effect on the plant height as well as grain yield. Petroczi *et al*. (2002)

suggested the application of herbicide like 2, 4-D on weeds had depressive side-effects depending on the wheat genotypes under field conditions. Khan *et al*. (2003) reported that application of 2,4-D at later stages of the wheat development reduced the yield and further reported that isoproturon 75 WP at 30 DAS application had a phytotoxic effect on the wheat crop. Ali *et al.* (2004) showed that herbicidal treatments of metribuzin and isoproturon + diflufenican produced smaller plants which can be due to their phytotoxic effect on wheat crop. Metribuzin and isoproturon + carfentrazone treated plots resulted in lowest plant height as compared with other herbicides. Oxidative stress was also induced.

Sikkema *et al*. (2007) reported that dicamba plus MCPA plus mecoprop at 600 g/ha decreased soft white winter wheat (SWWW) yield, however, when applied at 1200 g/ha, yield was decreased in all three years for both the SWWW and soft red winter wheat (SRWW). Kumar (2010) reported that herbicides (2,4-D and IPU) had phyto-depressive effects on Leaf area (cm^2), inter-node length (cm), shoot length (cm), biomass (fresh/dry weight g^{-1} $plant^{-1}$), seed weight (g $inflorescene^{-1}$), number of seeds $spike^{-1}$ at a range of concentrations applied (0-1200 ppm) alone and in combination. Singh *et al*. (2013) conducted an experiment to assess the effect of herbicides on growth and biochemical behaviour of wheat crop. The experiment comprised one wheat variety HUW-468 and four herbicides treatments, isoproturon, phenoxaprop-pethyl, sulfosulfuron and one untreated check. Plant height, number of tillers $plant^{-1}$ and leaf area index of wheat were reduced under herbicides treatments with respect to untreated check.

Effect of herbicides on nutrient uptake in wheat

Thakre and Saxena (1972) reported that application of 10 ppm DDT, 10 and 20 ppm aldrin and 10 ppm lindane increased uptake of nitrogen in wheat. But lindane @ 30 ppm reduced the uptake of nitrogen, phosphorus and potassium. DDT reduced the uptake of phosphorus in wheat. Osborne *et al*. (1993) studied the effect of the herbicides chlorsulfuron and diclofop-methyl on nutrient uptake found that chlorsulfuron decreased uptake of phosphorus and potassium were decreased while uptake of nitrogen was not affected. Brozowski (1997) found that total nitrogen content in grain increased from 1.79 per cent to 2.07 per cent with the herbicide use.

Yadav *et al*. (1997) reported that the herbicidal application showed a non-significant influence in nitrogen and phosphorus content, whereas, the uptake of other nutrients increased in wheat. Duhan *et al.* (2006) reported that the nitrogen uptake decreased significantly with the increasing levels of weedicide (200 to 400 g a.i. ha^{-1}) in both nitrogen and FYM treatments. Wagner and Nadasy (2009) reported that linuron herbicide caused the most severe dry matter decrease; at all N levels which were attributed to active ingredient inhibition of the photosynthetic process.

Majumdar *et al*. (2010) reported that nitrogen and phosphorus uptake was reduced with the application of herbicides. Sarmamy and Khidir (2013) reported that treflan caused significant decrease in the plant contents of total nitrogen, phosphorus, potassium in wheat plants.

Conclusion

Adoption of rice–wheat cropping system continuously without any fertilization proved deleterious to soil health because it resulted in a significant decrease in NPK over their initial levels in the soil. Application of Organic manures along with mineral fertilizers led to the greatest increase in NPK and higher uptake nutrients uptake and wheat yield. Moreover, chemical weed control was effective in controlling weeds and in some cases might shows harmful effects on nutrient uptake and wheat yield due to its phototoxic effects. These results imply that the integrated use of mineral fertilizers and organic manures along with herbicides represents a sound practice for sustaining NPK reserves in soil and hence enhancing NPK availability in wheat.

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