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Arvind Kumar
Barkatullah University Bhopal, Madhya Pradesh, India

Mohit
Indian Institute of Maize Research, P.A.U Campus, Ludhiana, Punjab, India

Corresponding Author:
Arvind Kumar
Barkatullah University Bhopal, Madhya Pradesh, India

Effect of irrigation and nitrogen management on performance and nitrogen removal under different tillage systems of wheat (*Triticum aestivum* L.)

Arvind Kumar and Mohit

Abstract
The stagnation of productivity growth in the rice-wheat systems of the Indo-Gangetic Plains in South Asia has led to increased calls for technologies based on conservation agriculture. Therefore, the present study was carried out to investigate performance and nitrogen removal as affected by irrigation and nitrogen management under different tillage systems in wheat. From the results, zero tillage with rice straw mulching produced similar grain yield to that of conventional tillage. Zero tillage with mulching showed the yield stability. From growth point of view, zero tillage with mulch method gave highest growth and yield contributing trait where first irrigation at 20 days after sowing and others at IW/CPE = 0.9 was produced maximum grain yield in both conventional as well as zero tillage. Zero tillage recorded significantly lower N uptake by crop than conventional tillage and zero tillage with mulch during both the years. At 150 kg N/ha maximum grain yield of wheat was recorded both in conventional tillage as well as zero tillage system.

Keywords: Irrigation, nitrogen management, tillage systems and wheat

Introduction
Wheat (*Triticum aestivum* L.), the second most important food crop of the world in terms of area and production meets 20 per cent of the total food, 19 per cent of calories and 20 per cent of protein requirements of the global population besides being a major source of dietary fibre in human nutrition since decades. It was grown in diverse environments across the globe over an area of 277 million hectares producing 654 million metric tons of grains with an average productivity of 3 tons ha^{-1} (Anonymous, 2017-18) [3]. In India wheat area has jumped up from 12.8 to 31.0 m ha^{-1} with corresponding increase in production from 11.4 to 88.9 mt from 1966-67 to 2016-17. The productivity of wheat is however very low in India in comparison to countries like UK (7.9 t ha^{-1}), Germany (7.8 t ha^{-1}), France (7.5 t ha^{-1}) and China (4.7 t ha^{-1}) on one or the other account. The situation is further grim in the state of Uttar Pradesh, a major wheat growing state in India with 36.6% area and 39.3% production despite the fact that Punjab and Haryana had been harvesting 4.36 t ha^{-1} & 3.91 t/ha, respectively. Future population and food requirement projections suggest
that India would require 324.5 m tons of food-grains and 91.5 m tons of wheat in 2025 for sustaining food security.
The stagnation of productivity growth in the rice-wheat systems of the Indo-Gangetic Plains in South Asia has led to increased calls for technologies based on conservation agriculture. To date, the most significant progress has been made by addressing the challenge of reducing tillage for wheat using tractor- drawn zero-tillage drills to seed the wheat crop into unplowed fields. The origin of zero-tillage wheat in rice-wheat systems can be traced to the importation of the prototype technology and adaptive research in the mid- to- late 1980s, followed by the subsequent creation of a local manufacturing capacity to supply adequate and affordable zero-tillage drills. Concerted efforts by an array of stakeholders that spanned public and private sectors and national and international research systems and included several persevering champions provided the institutional support for the technological opportunity to materialize.
Irrigation water is the most crucial input for wheat crop as growth; development and yield expression requires maintenance of suitable moisture in the root zone. Therefore, irrigation water should be used judiciously depending upon the type of soil, stage of the crop as well as evaporative demand of the atmosphere. Wheat crop is very sensitive to irrigation. Both excess and limited water causes yield loss. Improper scheduling of irrigation results not only in wastage of water, but also it decreases both crop growth and yield (Sekhon *et al.*, 1968) [11].

Balanced and efficient fertilizer application is essential to compensate for the increased yields and hence greater removal of soil nutrients. Nitrogen management is important in wheat crop because in rice-wheat cropping there is more depletion of nutrients as both the crops are cereal. Abrol *et al.* (1998) [1] also stated that productivity of the rice-wheat system has slowed down and that the use of productivity enhancing inputs appears to be approaching saturation. Long term fertilizer trials at Pantnagar conducted from 1984-1991 showed yield decline in rice-wheat cropping system regardless of treatments (Lal, 1998) [10]. Therefore, the present study was carried out to investigate performance and nitrogen removal as affected by irrigation and nitrogen management under different tillage systems vis-à-vis sustainability of wheat (*Triticum aestivum* L.).

Materials and methods

Experimental details

The Shamli town is located at the western boundary of Uttar Pradesh, 90 km to the north of the national capital Delhi 65 km. to south of Saharanpur city. Geographically the town is located at 20.6^0 N latitude and 77.15^0F longitude and at the elevation of 230.6 m above the mean sea level. The region receives on annual rainfall of about 65 cm extending over the period of mid July to October and few scattered rain showers during the winter months from the south-east monsoon.

The average minimum and maximum temperature the station in general varies from 5`C to 45`C. The farm has facility of tube well for irrigation.

A field experiment was conducted during the two consecutive cropping seasons of rabi season of 2007-2008 and 2008-2009 at Research Farm of R.K.P.G. College, Shamli, District Muzaffarnagar, (U.P), located at 20.6^0 N latitude and 77.15^0F longitude and at the elevation of

230.6 m above the mean sea level. The region receives on annual rainfall of about 65 cm extending over the period of mid July to October and few scattered rain showers during the winter months from the south-east monsoon. The average minimum and maximum temperature the station in general varies from 5`C to 45`C. During the experiment, it was observed that mercury touched a maximum of 45.1°C (8th week). The crop enjoyed a rainfall of 111.9 mm from sowing to harvesting at its various physiological stages of the year. Highest of this was during the eleventh week of the year, which, conceded to maturity stages of the crop. The minimum and maximum relative humidity observed during the investigation were 37.4% and 97.5% in the 20th and 7th week respectively. The experiment was laid out in split-split plot design, with four replications, keeping tillage management as main plot, irrigation as subplot and nitrogen management as sub- sub plot treatments. Further, the details of treatments were given to table.

Site descriptions

The experimental field was well drained, Silty clay loam in texture, medium in available potassium (155kg K_2O/ha), and medium in available phosphorus (22.6kg P_2O_5/ha). The soil was found to be slightly alkaline in reaction with ph 7.8 and E.C. of 0.6 mhos/cm at 25°C **(Jackson, 1973).** Which are presented in Table 1.

Table 1: Initial Electro-physico-chemical properties of soil with values and range

Character	Values
Soil texture	Silty clay loam
pH (1: 2.5)	7.7
EC (m mhos/cm at 25°C)	0.418
Organic carbon (%)	1.22
Available nitrogen (kg/ha)	220
Available phosphorus (kg/ha)	30
Available potassium	239

Crop management

Breeder seed of cultivar PBW-343 was sown at 20 cm row spacing with a seed rate 100 kg/ha with the help of devices as per treatments. Sowing under zero tillage treatment was done with the help of hired zero -till ferti- seed drill. The crop was fertilized with 120 kg N/ha, 150 kg N/ha and 180 kg N/ha as per nitrogen treatment, using urea. Phosphorus @ 60 kg/ha and potassium @ 40 kg/ha were given in all plots through single super phosphate and potassium sulphate, respectively, as basal.

Data collection

Observations on various parameters *viz*. shoot count m^{-2}, plant height (cm), plant dry weight (g/m^2) at maturity were recorded as per standard procedure. ear bearing shoots m^{-2} and grain yield (t/ha) was recorded by selecting 10 plants and yield was estimated by the produce obtained from net plot area, treatment wise.

Plant sampling and analysis

The plants measured for dry weight was used to analyze N content in grains and straw. The grain and straw samples were dried at 70 °C in a hot air oven. The dried samples were ground in a stainless steel Thomas Model 4 Wiley ® Mill. The N content in grains and straw was determined by digesting the samples in sulfuric acid (H_2SO_4), followed by analysis of total N by the Kjeldahl method (Page, 1982) using a Kjeltec™ 8000 auto analyzer (FOSS Company, Denmark). The uptake of the nutrients was calculated by multiplied the nitrogen content (%) with their yield (kg ha^{-1}) and then it was divided by 100 to get the uptake values in $kgha^{-1}$.

Statistical analysis

The data obtained were subjected to statistical analysis as outlined by Gomez and Gomez (1984) [7]**.** The treatment differences were tested by using "F" test and critical differences (at 5 per cent probability).

Results and discussion plant height

Amongst irrigation regimes maximum plant height at maturity was recorded in plants enjoying seven irrigations applied at 15 DAS, CRI, Late tillering, Late jointing, Flowering, Milking, dough (97.4 cm), which was significantly higher than the same recorded with I_1(86.6 cm) and I_2(91.4 cm). The height difference in plants enjoying six (95.8 cm) and seven irrigations (97.4 cm) did not varied significantly. During

2008-09 also the trend of response of irrigation was similar to 2007-08. During 2007-08, plant height recorded with 180 kg N/ha (91.5 cm), was significantly higher than120 kg N/ha (88.0 cm) but it was *at par* with 150 kg N/ha (89.4 cm). Similar response of nitrogen levels on plant height was observed during 2008-09 also. The similar results were also reported by Hill (1990) [8].

Dry matter accumulation

In general, conventional tillage recorded the *at par* dry matter accumulation to that under zero tillage with mulching during both the years. While zero tillage recorded significantly lower dry matter accumulation than conventional tillage and zero tillage with mulch in both the years. Beri *et al*. (1992) [4] also reported that bulk density under no-tillage without mulch increased and resulted in compaction of surface depth, which had a deleterious effect on crop growth. This effect, however, was mitigated when no-tillage was done with mulch. Moreover, dry matter accumulation, was recorded highest under seven irrigation condition during both the years. Among nitrogen management treatments, higher dry matter accumulation was recorded under nitrogen @ 150 kg N/ha but the effect was non-significant during both the years. Though, all three nitrogen treatments (N_1, N_2 and N_3) were *at par* in dry matter accumulation although N_2 (150 kg N/ha) showed maximum dry matter accumulation.

Ear bearing shoots

Significantly higher number of ear bearing shoots were recorded in zero tillage with mulching plot over zero tillage, but it was *at par* with conventional tillage during both the years. Amongst irrigation management treatments, all four irrigation treatments recorded *at par* number of ear bearing shoots during both the years. Although the number of spike bearing shoots recorded under Seven irrigations applied at15 DAS, CRI, Late tillering, Late jointing, Flowering, Milking, dough was higher than the other irrigation regimes but remained statistically at par. Amongst nitrogen levels highest number of ear bearing shoots were recorded with application of 180 kg n/ ha but the three nitrogen levels 120 kg N/ha, 150 kg N//ha and 180 kg N/ha recorded *at par* number of ear bearing shoot during both the years of experimentation.

Grain Yield

Among the tillage treatments, conventional tillage (Z_1) showed the significantly higher grain yield during first year. However, in second year the grain yield produced by conventional tillage (Z_1) is reduced by 1.56 per cent. This reduction in grain yield might be considered as reduction in number of effective shoots, lower test weight, low dry matter accumulation than first year. Singh *et al.* (1998) [13] also observed the decreasing trend of wheat grain yield with conventional tillage. The lowest yield was recorded under zero tillage (Z_2) treatment where lower yield is attributed to mainly high infestation of weeds which causes poor germination, lower dry matter accumulation, stunted growth, lower number of ear bearing shoots and ultimately lower grain yield. Singh *et al.* (1998) [13] and Dash and Verma (2003) [6] reported the similar reasons to decrease the wheat yield under zero tillage. Significantly lower yield of wheat was recorded under I_1 (four irrigations applied at CRI, late jointing, flowering, milking). Because, four irrigations were not sufficient to meet palnt's consumptive use for water. Thus due to water shortage the plants might failed to maintain desired level of photo-assimilate production and yield. The results are in accordence to. That's why the grain yield obtained under four irrigation water regime was significantly lower The similar finding was reported by Singh *et al.* (1977) [12]. The significant increase in grain yield was recorded under application of 150 kg N/ha over 120 kg N/ha and 180 kg N/ha. Increase in yield in N_2 (150 kg N/ha) plots was mainly due to the highest number of effective tillers m^{-2}, 1000-grain weight and dry matter accumulation during both the years. Similar results were also recorded by Ali *et al.* (2003) [2].

Nitrogen content in grain and straw

Slightly higher content of nitrogen in grain and straw was found in zero tillage with mulch sown crop than conventional tillage (Z_1) and zero tillage (Z_2) during first year, while conventionally tilled crop in second year. The results obtained was in close confirmity of Kumar (2001) [9] who noted the non-significant variation in nutrient concentration of plants due to different tillage methods. While the uptake of nitrogen, phosphorus and potassium by the crop was statistically influenced by various tillage treatments (Biswas and Benbi, 1989) [5]. Slight increase in nitrogen content in grain and straw in I_1 (Four irrigations) and during both the years was observed but the difference remained statistically non significant. Slight increase nitrogen content in grain and straw recorded in N_3 (180 kg N/ha) treatment during second year. But nitrogen levels also did not shown any significant difference. The results obtained was in close confirmity of Kumar (2001) [9] who noted the non-significant variation in nutrient concentration of plants due to different tillage methods. While the uptake of nitrogen, phosphorus and potassium by the crop was statistically influenced by various tillage treatments (Biswas and Benbi, 1989) [5].

Nitrogen uptake in grain and straw as well as total uptake

The maximum uptake of N was recorded from zero tillage with mulch plots during first year. It was *at par* with conventional tillage sown plots. Zero tillage alone treated plots registered the significantly lower uptake of nitrogen. During second year, significantly higher uptake of N by straw was noticed from the conventionally tilled plots. It was *at par* with zero tillage with mulch treated plots. The significantly lower N uptake by straw recorded in zero till plots. Total nitrogen uptake was significantly higher in conventionally tilled plots in both the years. It was *at par* with zero tillage with mulch treated plots. Zero tillage alone recorded significantly lower total nitrogen uptake than conventional tillage (Z_1) and zero tillage with mulch (Z_3) during both the years. Irrigation scheduling *i.e.* irrigations applied at 15 DAS CRI, Late tillering, Late jointing, Flowering, Milking, dough recorded significantly higher nitrogen uptake by grain and straw over I_1 (four irrigations) and remained at par to the rest of irrigation schedules during both the years. Least nitrogen uptake by grain and straw recorded in I_1 (Four irrigations applied at CRI, late jointing, Flowering, milking) during both the years. Similar trends were also noted in total uptake. Application of 150 kg N/ha showed significantly higher nitrogen uptake by grain and straw over N_2 (120 kg N/ha) and N_3 (180 kg N/ha) during both the years. Least uptake of nitrogen was recorded under 120 kg N/ha which was significantly lower than grain nitrogen uptake by other nitrogen levels. Similar trends were also noted in total uptake. The nutrient uptake seemed to be positively correlated with the grain yields produced. Since the essential nutrients are involved in the metabolism of plant, deficiency of one may limit the use or uptake of the other nutrient and this affects the

yields. The uptake of nutrients, therefore, followed the yield pattern (Biswas and Benbi, 1989) [5].

Conclusion

nitrogen @ 150 kg/ha and irrigation schedule of six irrigations at CRI, late tillering, late jointing, flowering, milking and dough can be adopted in zero tillage system to harness the agro resources and achieve maximum yield in wheat under zero till condition.

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