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Assessment of wheat production potential under different tillage and precision nutrient management

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Abstract
Field experiments were carried out to assess the wheat production potential under different tillage and precision nutrient management at D_3 Block of Norman E. Borlaug Crop Research Center in Govind Ballabh Pant University of Agriculture and Technology, Pantnagar at Uttarakhand, India, during the *rabi* season of 2015-16 and 2016-17. The experiment was laid out in strip plot design with three replications. Conventional tillage, reduced tillage and zero tillage practices were taken in horizontal strips while in vertical strips precision nutrient management practices like- control, recommended dose of fertilizer, site specific nutrient management and SSNM + Green Seeker, were taken. Test crop was wheat, variety DPW 621-50. Study revealed that significant increase in yield was recorded in reduce tillage over zero tillage while it showed at par results with conventional tillage in both the year. In precision nutrient management in year 2015-16 RDF showed significant increase of 89.6% and 10.2% in yield over control and SSNM+GS, respectively but was at par with SSNM treatment. Similar trend was followed in second year the increase in yield in RDF over control and SSNM+GS were 93.0% and 8.8%, respectively. Biological yield was significantly higher in reduced tillage in year 2015-16 while in year 2016-17 reduce tillage gave at par yield with conventional tillage but significant higher over zero tillage. In precision nutrient management higher biological yield was recorded in RDF treatment which at par with SSNM, SSNM+GS in year 2015-16 and SSNM in year 2016-17. Tillage and precision nutrient management practices failed to have significant effect on harvesting index in both the year. All the yield contributing characters like spike m^{-2}, spike length, grains/spike 1000-grain weight in both the year were found maximum in reduced tillage and RDF nutrient management practice.

Keywords: Conventional tillage, Green Seeker, NE^{TM} SSNM, Reduce tillage, Zero tillage

Introduction

Wheat (*Triticum aestivum* L.) is often known as "Miracle Crop" [1] as it contributes a major portion of staple food to the world's rising population. It is an important crop especially in Rice-Wheat Cropping System (RWCS) which is a major production system covering an area of 10 million hectares spread over the Indo-Gangetic Plains (IGP) and transformed itself from a "begging bowl" image to the status of "food bowl" of India [2]. In this rice-wheat cropping system paddy is grown in wetland culture which is the predominant soil management system adopted in India [3] and we take wheat as succeeding crop so there are two things to consider firstly, heavy land preparation during rice cultivation leading to destruction of soil structure, heavy energy requirement, and reduction of soil fertility, in results affect the soil quality and its environment during wheat cultivation [4]. Secondly after rice cultivation there is very less time left for the wheat field preparation and it is reported in the studies that delay in sowing of wheat crop after mid-November a day will lead to the yield reduction of one percent per [5].

Nutrient management is another important concept which has great significance in sequential cropping system of rice- wheat as both the crop are heavy feeder and the current approach of fixed-rate, fixed-time (blanket) fertilizer recommendations caused various limitations for large areas. This is mainly because this approach does not consider existence of large variability in soil nutrient supply and site-specific crop response to the particular nutrient [6] as it has also been reported that under and over fertilization are negatively affecting the desired growth pattern of plants which leads to the reduction in yield and soil health as well [7, 8]. That's why Nutrient Use Efficiency (NUE) is usually poor and is often not balanced with crop requirements and other nutrients [9, 10].

Therefore, a paradigm shift is needed for enhancing the system productivity and sustainability. In this aspect conservation tillage like No-tillage (NT) or reduced tillage, a combination of ancient and modern agricultural practices [11] will help not only to increase in crop yield but also it will maintain the good soil health as it is reported that appropriate tillage practices keeping soil properties in mind can enhance wheat production by 20 % [12]. There are other potential benefits including soil conservation and reduced production costs though saving in fuel, equipment and labour [13-15]. Similarly for nutrient management recent approaches like site-specific nutrient management (SSNM) provide an approach to “feeding crops” with nutrients as and when they are needed and hence making synergy for nutrient demand and supply under a certain production system enable more efficient use of fertilizers. These new nutrient management approaches will strengthen the agriculture through which field crops will receive appropriate rates of fertilizer to achieve optimal yields. As per today’s need various new equipments and software’s have already been designed for example decision support system (DSS) which is software based on the principles of SSNM (Nutrient Expert for wheat) that provides flexibility of using SSNM principles with and without soil testing and reaching large number of farmers. Considering all these problems and issues of conventional RWCS mentioned above the present study was designed to know the effect of different tillage practices and new tools for nutrient management to enhance the wheat productivity.

Material and method

The study was carried out in two consecutive years from 2015-2017 at D_3 Block of Norman E. Borlaug Crop Research Center in Govind Ballabh Pant University of Agriculture and Technology, Pantnagar (Uttarakhand, India). Pantnagar province is located at 29° N latitude, 79.29° E longitude in the north eastern part of India and an altitude of 243.84 m above the mean sea level. The experimental site belongs to *tarai* belt of Shivalik range of Himalayan foot hills. Soil of the experimental site was silty loam in texture with pH value 7.8, low in available nitrogen (245 kg/ha), medium in phosphorus (17 kg/ha) and potassium (145 kg/ha).

The experiment was designed in strip plot design where Three tillage practices conventional, reduced, zero were taken in horizontal strip and four precision nitrogen management practices control (0:0:0), RDF (150:60:40), SSNM (95:61:55) and SSNM + GS based (80.2:61:55 during 2015-16 and 89.1:61:55 during 2016-17) nutrient application were taken in vertical strips with three sets of replications. In conventional tillage four harrowing followed two rotavator were practiced and in reduced tillage, 50% of conventional tillage *i.e.* two harrowing followed by one rotavator while in zero tillage no tillage practices were performed and with the help of zero till seed drill seeds were placed in the furrows. In precision nutrient management control plots were maintained without the application of NPK, in RDF treatment one-third of nitrogen and full dose of phosphorous and potash were applied as basal and remaining two third of nitrogen were divided into half and top dressed at the time of CRI and flowering. In third treatment N was applied as SSNM with the help of Nutrient Expert^{TM} (NE) for wheat South Asia (version 1.0). It is a computer based decision support system that can assess the nutrient content to be applied on the particular field in the presence or absence of soil testing data. In fourth treatment nutrient was applied as 70 % of N and full P and K was applied as calculated in SSNM in addition to Green Seeker based N at 70DAS. An extra plot was maintained as a reference to calculate N doses to be applied in fourth treatment called N rich plot where N was applied @ 225 kg ha^{-1}. Irrigations were scheduled as per the crop need basis.

Results

1. Yield Contributing Characters

Among different yield contributing parameters spikes m^{-2} were found significantly higher in reduced tillage over conventional and zero tillage. RDF treatment gave the maximum spikes m^{-2} which was at par with SSNM treatment and significantly higher than SSNM+GS and control treatments in both the years.

Spike length basically is a genetic character but and this study comparatively long spikes were produced under reduced tillage though the effect were non-significant in both the year. In precision nutrient management longest spikes were formed in RDF treatment which was at par with SSNM and significantly higher than the SSNM+GS and control in year 2015-16. In the year 2016-17 under various precision nutrient management treatments longest spikes were formed in RDF which was at par with SSNM and SSNM+GS but significantly higher than and control. Number of grains per spike is one of the most crucial yield determining component and has directly related to the grain yield of wheat. In first year of experiment tillage practices failed to have significant effect over grains/spike while in year 2016-17 significantly higher grains/spike were produced under reduced tillage practice which was at par with conventional tillage. In both the year maximum grains/spike was formed in RDF treatment which was at par with SSNM and significantly higher than SSNM+GS and control. Thousand grain weight weight was non-significant under different tillage practices in both the year but significantly higher 1000-grain weight was found in RDF which was at par with SSNM, SSNM+GS but significantly higher over control in both the year. The reduce tillage and the higher nitrogen dozes favour to better partitioning of photosynthesis towards the sink.

Table 2: Yield attributes and yield of wheat in 2015-16 and 2016-17

Treatments	Spike m-2		Spike length (cm)		Grains /spike		1000-grain weight (g)		Grain yield (q ha-1)		Biological yield (q ha-1)		Harvesting Index (%)	
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
Tillage practices														
Conventional tillage	316	321	10.7	10.7	44	53	42.9	43.8	40.1	42.0	98.7	102.6	40.6	40.9
Reduced tillage	330	345	10.9	10.9	46	53	43.0	45.0	42.2	44.5	103.5	107.6	40.8	41.4
Zero tillage	300	302	10.7	10.5	41	48	41.7	42.2	38.6	40.0	95.0	95.4	40.6	41.9
SEm±	5.6	5.0	0.3	0.2	1.1	0.6	0.7	0.5	0.6	0.8	1.0	2.1	0.8	0.3
CD	22	19.6	NS	NS	NS	2.4	NS	NS	2.2	3.2	3.9	8.4	NS	NS
CV	6.1	5.3	8.7	5.9	9.0	4.3	5.9	4.1	5.0	6.7	3.5	7.2	6.5	2.2
Precision Nitrogen Management														
Control	183	193	10.1	9.1	40	41	39.9	40.7	25.0	25.8	61.8	62.8	40.5	41.1
RDF	384	392	11.3	11.4	47	56	44.5	46.0	47.4	49.8	115.3	118.7	41.1	42.0
SSNM	360	371	11.2	11.2	45	55	43.1	44.7	46.0	47.4	112.1	115.3	41.0	41.2
SSNM + GS	336	334	10.4	10.9	42	52	42.6	43.2	43.0	45.7	107.2	110.7	40.1	41.2
SEm±	13.0	9.0	0.2	0.2	1.3	1.1	0.7	1.0	1.0	1.1	2.6	1.8	0.5	1.0
CD (P=0.05)	45.1	30.8	0.7	0.5	4.4	3.9	2.3	3.6	3.2	3.7	9.3	6.4	NS	NS
CV	9.7	6.4	5.5	2.0	8.7	3.8	4.1	8.1	4.0	6.3	4.7	5.0	4.3	6.4

2. Yield

Grain yield in both the year was higher in reduced tillage which was at par with conventional tillage and significantly higher than zero tillage. Under precision nutrient management RDF produced significantly higher grain yield than the other treatments except SSNM in both the year. Biological yield in the year 2015-16 was significantly higher in reduced tillage practice while in the year 2016-17 showed at par biological yield with conventional tillage while significantly higher than the zero tillage. In 2015-16 RDF treatment produced higher biological yield which was at par with SSNM and SSNM+GS but significantly higher over control. In 2016-17 also RDF produced higher biological yield but this time it was significantly higher over SSNM+GS and control but remain at par with SSNM treatment. Harvest index is the physiological efficiency of crop plants to convert the photosynthates into grain yield. Harvest index mainly depends on the genetic potential of a cultivar and is influenced by different agronomic parameters. In both the year tillage and precision nutrient management over harvest index failed to produce significant effect over harvest index.

Discussion

Tillage is a physical manipulation of soil [16] and by performing zero and reduced tillage or minimizing the tillage practices there is certain change in soil physical chemical and biological properties of soil in terms of soil structure through good soil aggregates, porosity, mechanical resistance and water stability. The current status of water and soil regime in soil is directly related to the soil structure which simultaneously influences the biological and nutrient status in soil. In general the main objective of tillage practices is to reduce the compactness or the bulk density of soil to maintain the condition of good seed and soil contact, better soil aeration and roots of the plant receives mineral nutrients and water more easily which leads to better germination and better plant stand and ultimately improvement in yield performance as in reduced tillage condition [17, 18]. Yield is a summation of different contributing characters. So it is important that all the characters like spikes m^{-2}, spike length, grains/spike and 1000-grain weight should be in synchronization to produce maximum yield. It was observed that spikes m^{-2} was maximum in reduced tillage it might be due to good moisture availability during germination which leads to better crop stand. While In case of zero tillage seeds were placed through zero till seed drill machine which opened the furrow for seed placement in the standing crop residue. So the residue were collected in front of the shank and resulted in the unsuitable seed bed and uneven cultivation. Also since the machine was used direct sowing of seed in an unplowed soil, so seeds could not have a chance to contact with soil to absorb water and nutrition by plant roots and therefore lower yield product [17].
In reduced tillage conditions it has been observed that there is enough soil moisture for germination of wheat seeds and it has capacity to store moisture for long-term basis than the conventional tillage system and also increase the tillering capacity of the wheat plants [19] due to the favorable conditions available for physiological process as compare to conventional tillage. The number of tillers was significantly decreased by delay sowing due to less time are available for the physiological growth and development and high temperature trigger the grain filling stage in CT [20, 21].

In zero and reduced tillage system there is presence of more soil organic carbon (SOC) as compare to conventional tillage system. And increase in SOC is desirable as it is associated with good plat nutrition, crop performance and better soil health. Good SOC in surface soil is also considered as a primary indicator of soil quality [22]. Other plant nutrient like N, P and K are also found more in reduced and zero tillage [23, 24]. There is an increase in soil available K accumulation in both no till as well in reduced tillage as compared to the conventional system [25]. So all in one good physical and chemical condition of soil in reduced tillage system helped in the production of higher yield as compare to conventional and zero tillage.

On the other side in precision nutrient management practices through SSNM and SSNM+GS failed to produce increase in yield and yield contributing characters. It might be due to higher amount of N was supplied through recommended NPK practice than the other nutrient management practices. N is a constituent of the chlorophyll, which makes plant green and is responsible for higher photosynthesis. The rate of photosynthesis and the quality of photosynthetes determine the plant health, which finally decided the grain growth and yield. Thereby grain yield directly correlated with photosynthesis, which might be higher under recommended NPK [26].

Conclusion

From this study it is concluded that among all three tillage practices reduce tillage produced higher yield contributing characters and maximum grain and biological yield. Precision nutrient management through SSNM and recommended dose of fertilizer recorded at par grain and biological yield. Therefore, by applying the fertilizer on the need base of crop and cutting the amount of fertilizer it will be beneficial to apply nutrient on the basis of SSNM practice because it will not only giving at par yield with RDF but also taking care of good soil health by not disturbing the soil nutrient balance.

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