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Growth and Economic Assessment of Wheat under Tillage and Nitrogen Levels in Rice-Wheat System

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ABSTRACT

Mechanically post-harvest puddled rice field has stubbles that often delay timely planting of winter wheat crop. Zero tillage increased the net return by decreasing the unwise tillage operations and labor charges. Keep in view, a randomized complete block design experiment in a split plot arrangement was conducted with four tillage system [conventional tillage, CT; deep tillage, DT; zero tillage with zone disc tiller, ZDT; and happy seeder, HS] in main plots and five nitrogen levels [0, 75, 100, 125, and 150 kg·ha^{-1}] in subplots during 2009 to 2010 and 2010 to 2011 cropping seasons. Results showed that in 2009-10 and 2010-11 grain yield (4.6 Mg·ha^{-1} and 5.7 Mg·ha^{-1}) in DT and (4.5 Mg·ha^{-1} and 5.8 Mg·ha^{-1}) in HS were significantly higher compared with CT and ZDT. Significantly, maximum leaf area index (5.18 and 5.24) and crop growth rate (12.14 g·m^{-2}·d^{-1} and 13.15 g·m^{-2}·d^{-1}) were noted in DT. Grain protein (11.78%) was significantly higher in DT compared with CT, ZDT, and HS during 2009-10 and 2010-11. Total yield (12.4 Mg·ha^{-1} and 16.4 Mg·ha^{-1}) and grain yield (4.9 Mg·ha^{-1} and 6.5 Mg·ha^{-1}) at N_{125} kg·ha^{-1} while grain protein (13.52%) at N_{150} kg·ha^{-1} was significantly higher than other nitrogen levels. Maximum LAI (5.08 and 5.51) and crop growth rate (14.68 g m^{-2}·d^{-1} and 15.77 g·m^{-2}·d^{-1}) were recorded at N_{125} kg·ha^{-1} respectively. During both the years, all the tillage systems gave higher net return at N_{125} kg·ha^{-1} during both the growing seasons. DT and HS gave more than 20% higher yield and improved crop growth of irrigated wheat than CT and ZDT. Happy seeder provides immediate, identifiable, and demonstrable economic benefits by reducing production costs.

Keywords: Leaf Area Index; Grain Yield; Protein Content; Net Return; Wheat

1. Introduction

Rice-wheat cropping system has substantial role in world food security and provides about 8% staple grain to the world's population (Timsina and Connor) [1]. In South Asia, the area under rice-wheat cropping system is about 13.5 million hectares, which has meaningful role in food self-sufficiency (Saharawat *et al.*) [2]. In rice-wheat system, wheat yield is stagnant due to long-term use of conventional management practices, which exerts destructive effects on soil productivity and farm economics in post-harvest paddy field (Duxbury *et al.*) [3].

However, conventional tillage system reduces the soil compaction and enhances the nutrient stratification (Boydas and Turgut) [4]. Subsurface soil compaction by conventional tillage decreased both the nutrient and water use efficiencies and reduced the root growth of following wheat (Qamar *et al.*) [5]. Deep plowing breaks the sub-surface hard pan and improves the wheat crop growth and yield by increasing the rooting depth (Chaudhary *et al.*) [6]. No doubt, deep tillage has good response on crop yield due to fine seedbed preparation but it is expansive in terms of fuel and time (Qin *et al.*) [7]. Zero till wheat cultivation after rice is the most productive and resource-conserving technology (Erenstein *et al.*, 2007) [8]; Erenstein and Laxmi) [9], which has been successfully practiced on more than 111 million hectare

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worldwide (Derpsch *et al.*) [10]. It significantly decreases farming costs, soil erosion and improves ecosystem than conventional plowing (Sundermeier *et al.*) [11]. Continuous use of zero tillage practice considerably improves the net income of crop (Verch *et al.*) [12]. Moreover, zero tillage system gives equal to or even higher wheat grain yield than conventional plowed field (Qamar *et al.*) [5].

In rice-wheat cropping areas, different tillage systems are used for handling rice residues that have substantial effect on wheat yield and net profitability. Deep residues incorporation by disc plough or by mould-board plough is a better choice for effective disposal of residue and gives higher yield and net farm returns. Zero tillage recorded grain yield at par with deep tillage and higher than conventional tillage (Qamar *et al.*) [5] while net returns was higher than deep and conventional tillage systems (Kumar *et al.*) [13]. Zero tillage growers are the main beneficiaries by raising their farm income about US$100 per hectare and cost-saving effect is about US$52 per hectare due to reduction in tractor time and fuel for wheat seedbed preparation (Erenstein, 2009) [14]. It enhances the farmer's ability to practice in equitable, cost-efficient and sustainable way (Ladha *et al.*) [15]. The popularity of zero tillage is rapidly increasing due to its economic benefits. Zero tillage farmers gain net income of about US$93, whereas conventional growers get about US$74 per acre. Zero tillage gives an additional net benefit of US$19 over the conventional tillage (Directorate General Agriculture, (DGA) [16]. Zero tillage minimized the energy consumption, workloads of farm operations in the range of 15% - 50%, and enhanced the energetic productivity by 25% - 100% (Garcua-Torres) [17]. Landers [18] reported that if timing of entry and cost of ZT compared with the heavy tillage machinery, the farmers preferred to purchase ZT drills.

In rice-wheat cropping systems, nitrogen immobilization is a more critical problem in alternate year in rice-wheat crop production systems due to high values C:N of crop residues (Weisz *et al.*) [19]. In NT, crop residues remain on the soil surface and release of nitrogen slow due to N immobilization (Schomberg *et al.*) [20] than conventional tillage systems. If surplus amount of nitrogen fertilizer is applied in ZT field than crop requirement resulting in more leaching and volatilization, that will be greater than CT field losses (Cantero-Martıńez *et al.*) [21]. Current recommendations of N fertilization developed for continuously plowed systems, which may not be adequate for optimum production of wheat under NT (McConkey *et al.*) [22]. The main objective of current study was to compare and evaluate the growth, yield and economics of irrigated wheat in rice-wheat production system under conventional tillage, deep tillage, zone disc tiller, and happy seeder with different rates of N fertilization in a semiarid climate.

2. Materials and Methods

2.1. Study Site

The study was conducted in a rice-wheat system at the research farm of the University of Agriculture, Faisalabad (latitude 31˚26'N and 73˚06'E, altitude 185 m) in 2009 to 2010 and 2010 to 2011 growing seasons. The soil is the Hafizabad series (fine-loamy, mixed, hyperthermic, Typic Calciargids) and the soil texture is sandy clay loam (Khan, 1986) [23]. Selected chemical and physical characteristics were done before sowing: pH 7.7 ± 0.1, electrical conductivity 2.82 ± 0.3 $dS \cdot m^{-1}$, soil organic matter content 0.73%, total N 0.04%, available phosphorus 62 $mg \cdot kg^{-1}$, exchangeable potassium 83 $mg \cdot kg^{-1}$, and sand 53%, silt 20% and clay 27%.

2.2. Experimental Design and Cultural Practices

A randomized complete block design in split plot arrangement with three replications was carried out in 2009 in a post-harvest puddle rice field. Four tillage systems (conventional tillage, CT; deep tillage, DT; zero tillage with zone disk tiller, ZDT; and happy seeder, HS) were randomized in the main plots while five levels of nitrogen [0, (N_0); 75 (N_{75}); 100 (N_{100}); 125 (N_{125}); and 150 (N_{150}) $kg \cdot ha^{-1}$] were applied in 5.4 m by 8 m as subplots. Wheat (var. Sahar 2006) was planted @ rate of 125 $kg \cdot ha^{-1}$ in the third week of November 2009 at 23 cm apart between rows having 24 rows in each replicated plot. Phosphorous and potash fertilizers were applied at 100 and 60 $kg \cdot ha^{-1}$, respectively. A full rate of phosphorous and potash and half of the N were applied at planting. The remaining half of the N was applied with first irrigation. Topik 15 WP (Trade name) at 1250 g powder ha^{-1} was applied to control weeds.

2.3. Calculation of Net Return (Rs. ha^{-1}) of Wheat

Net return was determined by subtracting the total cost of production from the gross income of each treatment (CIMMYT 1988) [24].

Net income = Gross income − Cost of production

3. Statistical Analysis

Data were analyzed statistically using SAS (SAS Institute) [25]. The effects of tillage and N levels their interaction were evaluated by the least significant difference (LSD) test at $p \leq 0.05$ unless otherwise mentioned.

4. Results and Discussion

4.1. Tillage and Nitrogen Fertilization Effects on Wheat Yield and Protein Content

Tillage and nitrogen plays a vital role not only in grain yield but also in grain quality. Tillage had significant effects on yield and grain protein content of wheat (**Table 1**). Wheat grain yield in first year of study was significantly higher (4.6 $Mg \cdot ha^{-1}$) in DT followed by HS (4.5 $Mg \cdot ha^{-1}$) as compared with CT and ZDT. Grain yield in DT was 17 to 23% while in HS was 15 to 22% higher than ZDT and CT. In contrast, significantly higher grain yield was noted (5.8 $Mg \cdot ha^{-1}$) in HS followed by DT (5.7 $Mg \cdot ha^{-1}$) as compared with CT and ZDT during 2010 to 2011 growing season. Similarly, the highest total wheat yields were attained in DT and HS over other treatments in both years. Significantly, maximum grain protein contents were observed in deep tillage and minimum was observed in zero tillage systems (Happy seeder and zone disc tiller) during both the growing seasons.

In both the years of study, nitrogen fertilization had

Table 1. Tillage systems and nitrogen levels interaction on total and grain yield and protein content of irrigated wheat in Faisalabad, Pakistan (data of 2009-10 and 2010-11 growing season).

Tillage system	Nitrogen level ($kg \cdot ha^{-1}$)	Total yield ($Mg \cdot ha^{-1}$)		Grain yield ($Mg \cdot ha^{-1}$)		Protein content (%)	
		2009-10	2010-11	2009-10	2010-11	2009-10	2010-11
	0	5.9d$^{\Psi}$	8.5c	3.0c	3.3d	8.40e	8.41e
	75	10.4c	13.7b	4.1b	5.4c	11.57d	11.58d
	100	11.6b	15.6a	4.6a	6.2b	12.25c	12.25c
	125	12.4a	16.4a	4.9a	6.5a	12.96b	12.98b
	150	11.4b	14.8ab	4.6ab	6.1b	13.52a	13.52a
				Tillage × N interaction			
CT	0	5.4	7.8	2.0	3	8.40	8.42
	75	9.8	13.5	3.8	5.3	11.56	11.58
	100	10	15.3	3.9	6	12.26	12.26
	125	10.3	16.2	4.1	6.4	12.96	12.98
	150	9.5	14.1	3.8	5.6	13.52	13.52
		9C*	13.4A	3.5B	5.3B	11.74B	11.75B
DT	0	4.9	9.2	1.9	3.6	8.45	8.46
	75	11.6	13.7	4.6	5.4	11.59	11.61
	100	13.2	15.8	5.3	6.3	12.29	12.29
	125	14.5	16.6	5.8	6.6	13.01	13.02
	150	13.7	16.2	5.5	6.5	13.55	13.54
		11.6A	14.3A	4.6A	5.7A	11.78A	11.78A
ZDT	0	6	8	2.4	3.1	8.37	8.38
	75	9	13.4	3.6	5.3	11.55	11.56
	100	10.8	15.4	4.3	6.2	12.22	12.22
	125	11.5	15.9	4.6	6.3	12.93	12.95
	150	10	14.3	3.9	5.7	13.49	13.50
		9.4B	13.4A	3.8B	5.3B	11.71C	11.72C
HS	0	7.3	9	2.9	3.5	8.38	8.39
	75	11	14	4.4	5.6	11.56	11.57
	100	12.4	15.9	5.0	6.4	12.23	12.23
	125	13.3	17	5.3	6.8	12.94	12.96
	150	12.7	16.5	5.1	6.6	13.50	13.51
		11.4A	14.5A	4.5A	5.8A	11.72BC	11.73C
	Tillage × Nitrogen	1.1	ns	ns	0.3	ns	ns

CT = Conventional tillage. DT = Deep tillage. ZDT = Zone disc tiller (zero tillage drill). HS = Happy seeder (zero tillage drill). LSD $p \leq 0.05$; $^{\Psi}$ = Means separated by lower case letter in each column are not significantly different among nitrogen fertilization rates at $p \leq 0.05$. * = Means separated by upper case letter in each column are not significantly different among tillage treatments at $p \leq 0.05$.

significant influenced on the yield and protein content of irrigated wheat (**Table 1**). During both the years of study, significantly higher wheat grain yield was recorded at N_{125} kg·ha^{-1} that was 49, 16, 4 and 4% greater than N_0, N_{75}, N_{100} and N_{150} kg·ha^{-1}, respectively. Similarly, higher total yield was in N_{125} kg·ha^{-1} that was 50, 16, 5 and 5% greater than N_0, N_{75}, N_{100} and N_{150} kg·ha^{-1}, respectively in both the years. In 2009 to 2010 and 2010 to 2011 growing years, maximum grain protein content was observed when wheat crop fertilized with nitrogen @ 150 kg·ha^{-1} followed by N_{125} kg·ha^{-1} and minimum was noted at N_0 kg·ha^{-1}.

In the 2009 to 2010 growing season, tillage × nitrogen interaction significantly influenced total yield while grain yield in second year and grain protein content remained non-significant during both the growing seasons. However, deep tillage and happy seeder under N_{125} kg·ha^{-1} produced significantly higher yield of wheat over other tillage × nitrogen combinations.

Deep tillage produced significantly higher total and grain yield of wheat that was associated with better seedbed preparation, higher soil porosity and greater water and nutrient availability (Khan *et al.*) [26] while lower yield under CT was due to subsurface soil compaction which may have hindered root growth (Lopez-Bellido *et al.*, 2007) [27]. In several studied, consistently higher yields in HS and DT than in CT were reported (Sip *et al.*) [28]. Significantly higher grain yield in HS was observed due to cooler and maximum soil moisture content than CT and DT, which improved water use efficiency of crops (Su *et al.*) [29]. Happy seeder produced higher grain yield than zone disc tiller in both the year due to seed cover by rice straw (Morris *et al.*) [30] which reduced moisture evaporation and improved seed-to-soil contact. In case of zone disc tiller, furrow opener was not covered by rice straw that decreased seed germination and resulted in lower yield (Tessir *et al.*) [31]. Deep tillage had longer root length due to deep plowing that increased the nutrient and water use efficiency (Qamar *et al.*) [5] which help in increasing the grain protein content (Cociu and Alionte) [32]. However, lower grain protein content in zero tillage was due to higher soil bulk density and penetration resistance, which reduced the root length and ultimately lower the protein content (Vita *et al.*) [33]. Significantly, higher grain protein content was also reported due to better root growth and nutrient use efficiency in zero tillage (Coventry *et al.*) [34].

Nitrogen fertilization had significant effects on the yield and protein content during both the years of study. It is reported that total and grain yields increased by increasing nitrogen fertilization, but excess of nitrogen often decreased the yields because other yield components of wheat are decreased with an associated decrease in vegetative growth (Khan *et al.*) [35]. Similarly, Tavakoli and Oweis [36] reported that with irrigation, the response of winter wheat to nitrogen significantly increased up to 60 kg·ha^{-1}. Both the years of study at higher nitrogen levels higher grain protein was noted. Hussain *et al.* [37] reported that nitrogen fertilizer levels affect the protein contents and increased by increasing the nitrogen rates. The higher water and nutrient use efficiency in deep tillage and in happy seeder at nitrogen fertilization 125 kg·ha^{-1} was favored to produce higher yields (Qamar *et al.* [5]. Grain protein content was not affected by increasing the total and grain yield during second year of study.

4.2. Tillage and Nitrogen Fertilization Effects on Wheat Growth

Leaf area index (LAI) and crop growth rate (CGR) are the basic physiological parameters, which showed the size of crop assimilates and rate of dry matter accumulation per unit area respectively. Significant effect of different tillage systems and nitrogen fertilization on LAI and CGR were found in both the growing seasons (**Figures 1-4**). Leaf area index of tillage system in both the growing seasons (**Figure 1**) line curve increased gradually and attained the peak at 75 days after sowing (DAS). After 75 days, the line started to decreased and reached lower point at 135 DAS. The line curve of deep tillage remained above than the other tillage systems during both the growing seasons. Maximum leaf area index (5.18 and 5.24) was attained at 75 days by deep tillage followed by happy seeder and minimum was noted in conventional tillage. In both the growing years, CGR (**Figure 3**) of tillage system increased and attained maximum level at 75 DAS. After 75 days, it decreased slowly up to 95 DAS then sharp decline up to 115 DAS. After 115 days, CGR decreased but comparatively at lower rate. The line curve of deep tillage remained higher than conventional tillage, zone disc tiller and happy seeder throughout the growing seasons. Deep tillage in both years of study produced the maximum crop growth rate of 12.14 g·m^{-2}·d^{-1} and 13.15 g·m^{-2}·d^{-1} followed by happy seeder and minimum CGR was noted in conventional tillage.

During both the years (**Figure 2**) leaf area index of wheat crop was maximum when fertilized with N_{125} kg·ha^{-1} followed by N_{100} kg·ha^{-1} and minimum was observed in N_0 kg·ha^{-1}. The line curve of leaf area index at N_{125} kg·ha^{-1} remained above of N_{150}, N_{100}, N_{75} and N_0 kg·ha^{-1} throughout the growing seasons. In both the years, maximum LAI of 5.08 and 5.51 were observed at N_{125} kg·ha^{-1}. The line curve of crop growth rate at N_{125} kg·ha^{-1} (**Figure 4**) remained higher during both the growing seasons and attained maximum crop growth rate

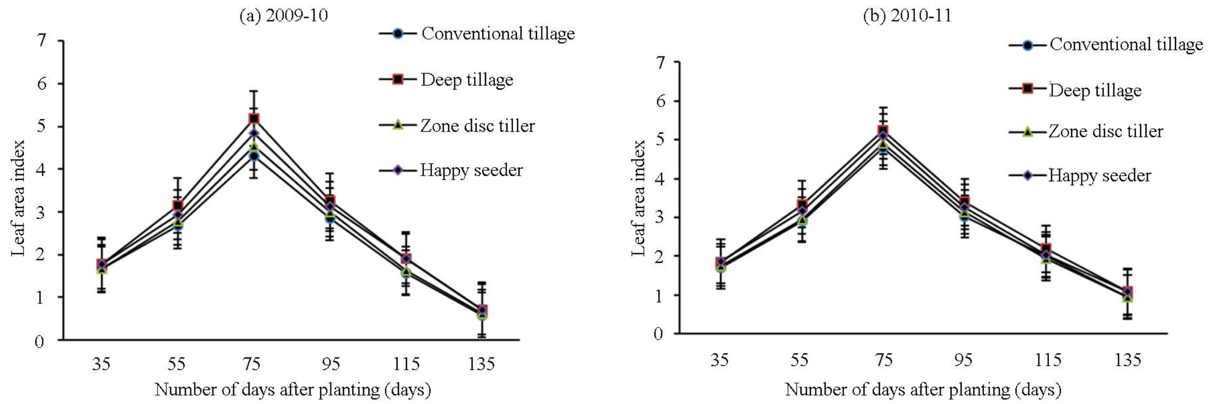

Figure 1. Leaf area index as affected by different tillage systems.

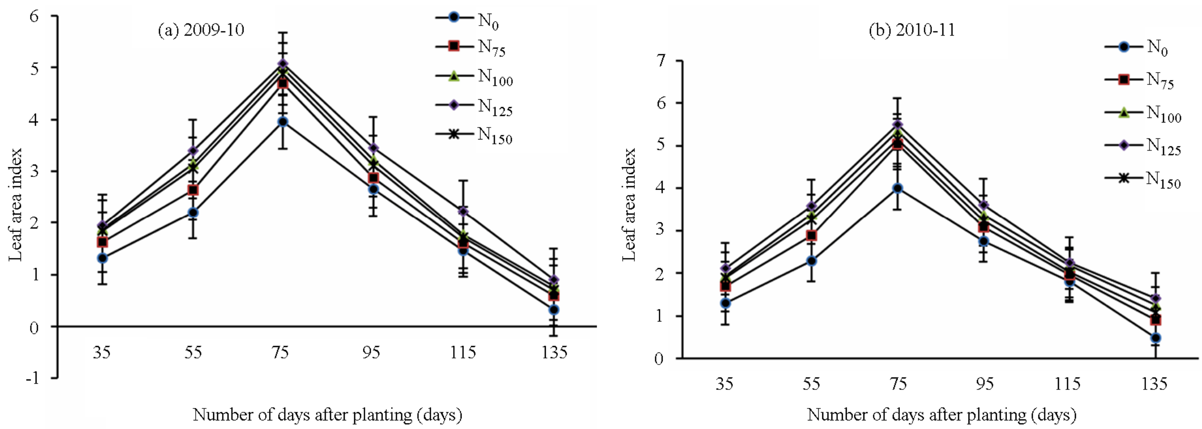

Figure 2. Leaf area index as affected by different nitrogen levels.

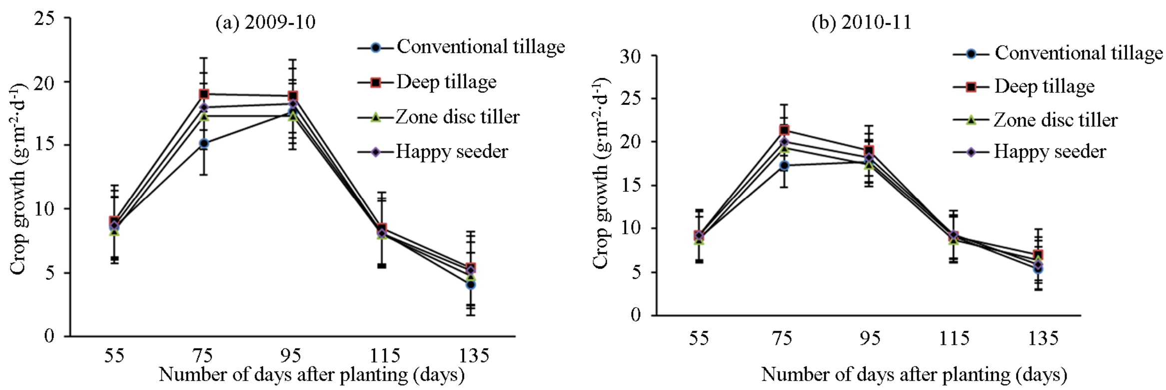

Figure 3. Crop growth rate as affected by different tillage systems.

of 14.68 $g \cdot m^{-2} \cdot d^{-1}$ and 15.77 $g \cdot m^{-2} \cdot d^{-1}$, followed by N_{100} $kg \cdot ha^{-1}$ and minimum was noted at N_0 $kg \cdot ha^{-1}$. Decline in CGR at 75 days was less in 2009-10 while in the succeeding year this decline was sharp which might be attributes to variation in climatic conditions.

In first year mean maximum temperature from 75 DAS to 95 DAS was increased while in second year the mean maximum temperature was decreased from 75 DAS to 95 DAS. It is clear that during both the growing seasons there was significant difference in leaf area index and crop growth rate not only among tillage systems but also between the various nitrogen levels. In both the growing seasons, all the tillage systems gave maximum crop growth parameters @ N_{125} $kg \cdot ha^{-1}$ followed by N_{100} $kg \cdot ha^{-1}$ and minimum was noted at N_0 $kg \cdot ha^{-1}$. Significantly higher LAI and CGR in deep tillage was due to fine seedbed and longer root length that favored nutrient and water use efficiency, which positively affected the

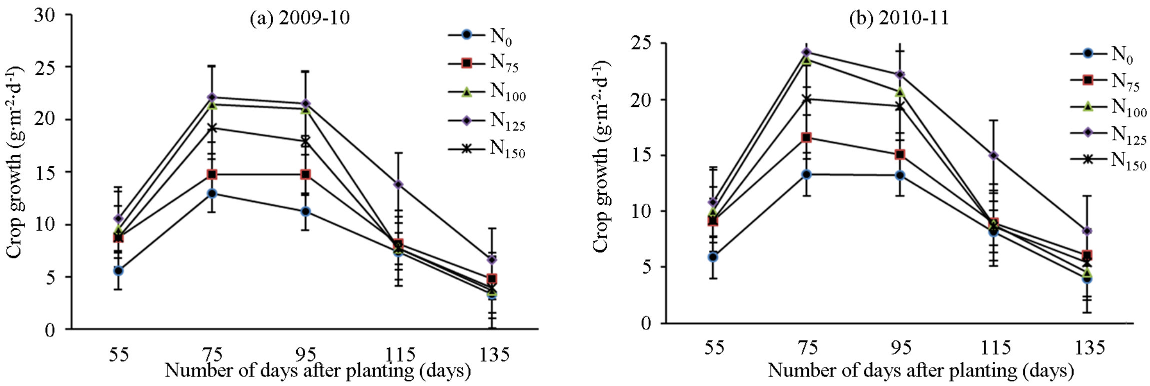

Figure 4. Crop growth rate as affected by different nitrogen levels.

Table 2. Effect of different tillage systems and nitrogen levels on net return of irrigated wheat (data of 2009-2010 and 2010-2011 growing seasons).

Treatment		Gross income (Rs. ha^{-1})		Variable cost (Rs. ha^{-1})		Total cost (Rs. ha^{-1})		Net Return (Rs. ha^{-1})	
		2009-10	2010-11	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11
CT: Conventional tillage	N_0: No nitrogen	61100	90450	6531	9809	80351	83692	−19251	6746
	N_{75}: 75 kg·N·ha^{-1}	114250	158675	15434	21563	89242	95453	24996	63217
	N_{100}: 100 kg·N·ha^{-1}	117025	179700	16653	25144	90479	99039	26552	80661
	N_{125}: 125 kg·N·ha^{-1}	122175	191200	18271	27813	92085	101708	30084	89492
	N_{150}: 150 kg·N·ha^{-1}	113050	167000	18376	26688	92184	100583	20854	66417
DT: Deep tillage	N_0: No nitrogen	57125	107900	6199	17756	80025	85651	−22894	22249
	N_{75}: 75 kg·N·ha^{-1}	137250	161050	18046	21896	91855	95779	45384	65259
	N_{100}: 100 kg·N·ha^{-1}	157475	187625	21237	26118	95051	100018	62418	87612
	N_{125}: 125 kg·N·ha^{-1}	172550	196350	23829	28478	97637	102361	74901	93977
	N_{150}: 150 kg·N·ha^{-1}	163425	193175	23910	29633	97736	103522	65695	89647
ZT: Zone disc tiller	N_0: No nitrogen	71400	93225	7838	10118	73658	76018	−2258	17212
	N_{75}: 75 kg·N·ha^{-1}	107500	158275	14769	21564	80589	87453	26911	70816
	N_{100}: 100 kg·N·ha^{-1}	128125	184050	17959	25809	83785	91692	44346	92346
	N_{125}: 125 kg·N·ha^{-1}	136850	187625	19909	27481	85718	93381	51121	94249
	N_{150}: 150 kg·N·ha^{-1}	116625	170175	18685	27020	84511	92909	32120	77260
ZT: Happy seeder	N_0: No nitrogen	86475	104325	9476	11424	75290	77325	11179	27006
	N_{75}: 75 kg·N·ha^{-1}	131300	166600	17382	22538	83202	88433	48098	78167
	N_{100}: 100 kg·N·ha^{-1}	148750	190400	20263	26450	86071	92345	62667	98055
	N_{125}: 125 kg·N·ha^{-1}	157875	201900	22190	29119	88004	95015	69865	106886
	N_{150}: 150 kg·N·ha^{-1}	151525	196350	22604	29965	88430	95848	63101	100490

Wheat grain price (2009-10 and 2010-11) = Rs. 950 per 40 kg. Wheat straw price = Rs. 160 per 40 kg. Threshing charges = 5.5 kg per 40 kg. Wheat grain price = Rs. 23.75 per kg. Conventional and deep tillage charges = 11500 ha^{-1}. Zone disc tiller and happy seeder charges = 3500 ha^{-1}. Urea charges (2009-10) = Rs. 875 per bag. Urea charges (2010-11) = Rs. 1250 per bag. Application charges = Rs. 250. Total permanent cost (2009-10) = Rs. 62320. Total permanent cost (2010-11) = Rs. 62395.

plant growth (Kosmas *et al.*) [38]. In case of zero tillage (Happy seeder), produced higher growth parameter than conventional tillage was due to moisture and nutrient availability near the soil surface that enhanced the growth. Crop growth parameter like leaf area index and crop growth rate were increased by increasing the nitrogen levels because nitrogen fertilizer boost up the plant growth up to certain level and produced more vegetative growth (Warraich *et al.*) [39]. Moreover, significant difference in wheat growth and yields between growing seasons was due to the variations in air temperatures, amount of rainfall and relative humidity. The weather of the 2010 to 2011 growing season was more favorable to irrigated wheat growth and yield compared to the weather conditions in 2009 to 2010 growing season.

4.3. Tillage and Nitrogen Fertilization Effects on Wheat Economics

Economic analysis is essential to check the profitability and net return of the system. Farmers are more interested in variable costs and economic return of newly introduced enterprises. Economic analysis assist researcher to plan their research for detail investigation and make decision, which provides base for recommendations to the farmers. The variability in net return is more important than variability in crop yield (Jabran *et al.*) [40]. Net return was calculated during both the years (2009-10 and 2010-11) (**Table 2**). In second growing season, the environment during the whole crop period was good and timely rainfall at critical stages well supported the growth of wheat. The yield in the second year 2010-11 (**Table 1**) was more than in year 2009-10. During both the years conventional tillage (Rs. 30084 and Rs. 89492), deep tillage (Rs. 74901 and Rs. 93977), zone disc tiller (Rs. 51121 and Rs. 94249) and happy seeder (Rs. 69865 and Rs. 106889) gave maximum net return at N_{125} $kg \cdot ha^{-1}$. All the tillage systems gave minimum net return at control during both the years. Wheat crop planted with zero tillage (Happy seeder and zone disc tiller) gave higher net return than conventional methods of sowing during both the growing seasons. In zero tillage, low fixed cost of production and higher grain yield with respect to conventional tillage system gave maximum net return at all nitrogen levels. The yields of all the combinations were statistically at par but the difference in net return was due to less cost of production in zero tillage as compared with conventional method. In rice-wheat cropping system, zero tillage were produced higher grain yield than conventional tillage and the primarily cost saving technology, which gave maximum net return (Erienstien *et al.*, 2008) [41].

5. Conclusion

Deep tillage and happy seeder (zero tillage) gave more than 20% higher yield than conventional tillage and zone disc tiller (zero tillage) and improved crop growth of irrigated wheat after puddle rice. However, deep tillage along with N_{150} $kg \cdot ha^{-1}$ had greater grain protein content than any other tillage systems and nitrogen levels. The higher crop yield in zero tillage (happy seeder) than conventional method of sowing was due to timely crop establishment that resulted in form of improved crop yield. Moreover, happy seeder (zero tillage) provides immediate, identifiable, and demonstrable economic benefits by reducing production costs. All the tillage system gave the maximum net return at N_{125} $kg \cdot ha^{-1}$. The maximum net returns was noted in zero tillage that was due to economic superiority over conventional method of sowing.

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