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RESPONSE OF MAIZE (*Zea mays* L.) TO DIFFERENT TILLAGE REGIMES AND NITROGEN TIMINGS UNDER SEMI-ARID IRRIGATED CONDITIONS

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Soil ploughing up to required depth and time of nitrogen application at different growth stages are important practices for enhancing crop yield. The effect of different tillage systems and nitrogen application at different growth stages on yield and yield components of hybrid maize was studied through 2-years field experiment. The experiments were laid out in RCBD with split plot arrangements and main plots were allocated to tillage treatments viz. (T_1: Conventional Tillage (2-Cultivation), T_2: Tillage with mould board plough + 2-Cultivation, T_3: Tillage with Chisel plough + 2-Cultivation) while subplots to nitrogen timings viz. (Whole at sowing (N_1), ½ at sowing + ½ at V_5 (5-leaf stage) (N_2), ½ at sowing + ½ at tasseling (N_3), ½ at V_5 + ½ at tasseling (N_4), 1/3 at sowing + 1/3 at V_5 + 1/3 at tasseling (N_5). The results indicated significant improvement of yield and yield components through tillage and split application of nitrogen. Plots ploughed to deeper layers with chisel plough resulted higher grains weight per cob (127.65±3.43; 134.45±3.66), 1000-grain weight (272.18±3.33; 306.40±3.08) and grain yield (6.30±0.11; 7.04 ±0.13) during 2008 and 2009, respectively. Nitrogen application in three splits i.e. $^1/_3$ at sowing + $^1/_3$ at V_5 + $^1/_3$ at tasseling resulted increased grains weight per cob, 1000-grain weight and grain yield. Interactive effect of tillage and nitrogen treatments on maize gain yield found significant in 2008 while non-significant in 2009. Higher grain yield was recorded with chisel plough along with N application in three splits during both study years. From current study, it may be concluded that farmers should grow maize hybrids by cultivating the soil using chisel plough along with cultivator and applying nitrogen in three splits to obtain higher grain yield.
Keywords: Grain yield, maize, split application of nitrogen, 1000-grain weight, tillage.

INTRODUCTION

In Pakistan farmers of irrigated area plough their lands with shallow tillage implements (simple cultivator) due to less energy cost (fuel consumption) than deep tillage implements in addition to non-availability of deep tillage implements. Repetitive use of same implement for tilling the soil creates a hard pan in the subsoil layer. Presence of hard pan leads to poor soil physical properties such as higher soil bulk density and penetration resistance (Raza *et al.*, 2005) consequently leading to lesser crop yield. Subsoil compaction limits the root length of crops due to higher subsoil bulk density (Ishaq *et al.*, 2001) and resulted to reduction in yield (Coelho *et al.*, 2000) due to less absorption of nutrients and water (Motavalli *et al.*, 2003). The most serious cause of subsoil compaction is the continuous cultivation of soil with same tillage implements which affects the soil physical properties (Ahmad *et al.*, 2009) and adversely affect the crop yield (Wasaya *et al.*, 2011). Among various options for managing the remediation of subsoil compaction are crop rotation and subsoiling (Motavalli *et al.*, 2003). Subsoiling improves the NRE (nitrogen recovery efficiency) and greater NRE was observed from plots with subsoiling treatments as compared to compacted plots (Motavalli *et al.*, 2003). Tillage with moldboard plough along with disk harrowing improves wheat root length density and root biomass compared with no-tillage due to more soil penetration resistance in no-till plots in the upper soil layer (Munoz-Romero *et al.*, 2010). Similarly subsoiling improves the crop yield upto 24% compared with other tillage practices (Botta *et al.*, 2006). Yield increment under conventional tillage compared with reduce and zero-tillage occurs due to more availability of soil P and K contents in the former tillage system and the others resulted to yield reduction of 11.28% and 6.31% under zero-tillage and reduced tillage respectively (Gangwar *et al.*, 2004).

Farmers of irrigated area generally apply nitrogen at crop sowing or with second irrigation in maize which undergoes different losses in the form of volatilization, denitrification and leaching. Reduction of nitrogen losses and enhancing nitrogen use efficiency (NUE) through higher crops yield is the ultimate goal. To increase NUE, time of N application or split application is a vital component. Pre-plant nitrogen application is subjected to more NO_3^- leaching compared with side dressing. Application of nitrogen in different splits

reduces NO_3^- leaching (Mitchell *et al.,* 2000) and results in higher corn yield (Bakhsh *et al.,* 2002; Jamil *et al*., 2015).
Soils having sandy texture are more liable to nitrogen losses in the form of leaching especially during periods of high rainfall which can be reduced through splitting and delayed N application to the crop at the time of need. Splitting N into 3-4 splits resulted in higher grain yield and agronomic efficiency by minimizing N volatilization losses in the form of ammonia (ViswaKumar *et al.,* 2008), when N applied between 30-60 days after emergence (Sitthaphanit *et al.,* 2010). Similarly, significantly higher kernel yield is obtained when nitrogen applied in three spits i.e. at emergence, V_5 and pre-tasselling (Arif *et al.,* 2010).
Farmers are facing a lot of problems for growing crops. Non-availability and high cost of fertilizers and deep tillage implements are the major problems. In addition, unnecessary ploughing of soil and improper timing of nitrogen application are serious threats to maize production. Hence there is a dire need for spatial and temporal application of fertilizers especially the nitrogen and subsoiling to reduce compaction for improving nitrogen use efficiency and crop yield. Studies on tillage and split application of nitrogen in hybrid maize under semi-arid conditions of Faisalabad, Pakistan are lacking. Therefore, the present study was, undertaken to evaluate the impact of different tillage systems and temporal application of nitrogen at different growth stages on yield and yield components of hybrid maize under semi-arid (irrigated) conditions.

MATERIALS AND METHODS

***Site description*:** The experiment was conducted in the University of Agriculture, Faisalabad (Pakistan) which is located at longitude 73° East and latitude 31° North. The altitude of site is 135 meters above the sea level. The experimental soil is sandy clay loam with an organic matter of 0.69%. Daily meteorological data (rainfall and temperature) for the whole crop season for both years is presented in the Figure 1. Part of this study is also published as Wasaya *et al.* (2012).

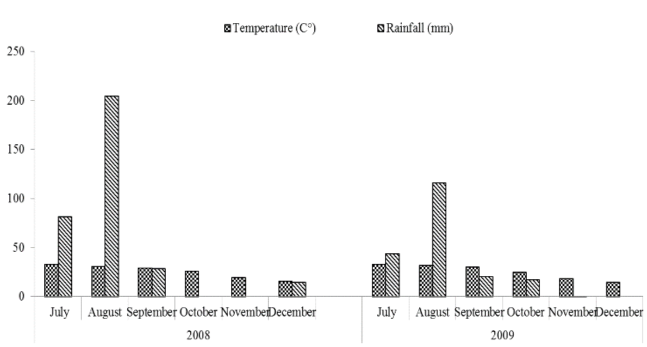

Figure 1. Rainfall and temperature data during the experimental years 2008 and 2009.

***Experimental procedure*:** Before crop sowing the soil samples were taken from the field for different soil physico-chemical properties given in Table 1. The field selected for experiment was previously cropped under wheat. The experiment was laid out in randomized complete block design (RCBD) with split plot arrangement and replicated thrice in a net plot size of 4.5m × 10m (sub-plot). Tillage treatments were applied to main plots and split application of nitrogen to sub-pots. Tillage treatments were; conventional tillage (T_1), tillage with mould board plough followed by 2-cultivations (with cultivator) (T_2), tillage with chisel plough followed by 2-cultivations (with cultivator) (T_3). Field was cultivated with tractor mounted cultivator in case of conventional tillage upto a depth of 15 cm twice followed by planking. In second treatment (T_2) the field was ploughed with mould board plough upto a depth of 30 cm followed by two cultivations and planking. In third treatment (T_3) the field was ploughed with chisel plough upto a depth of 40 cm followed by 2-cultivations and planking. Nitrogen application timings were; Whole at sowing (N_1), ½ at sowing + ½ at V_5 (5-leaf stage) (N_2), ½ at sowing + ½ at tasseling (N_3), ½ at V_5 + ½ at tasseling (N_4), 1/3 at sowing + 1/3 at V_5 + 1/3 at tasseling (N_5). Before maize sowing soaking irrigation of 10 cm was applied and final seedbed was prepared when field reached at proper moisture level after six days of soaking irrigation. Maize hybrid pioneer-31R88 was sown on 16th August 2008 and 10th August, 2009 at a seeding rate of 25 kg ha^{-1} with line to line distance of 75 cm and a plant-plant distance of 20 cm with the help of dibbler. Two seeds were planted per hill and then one plant per hill was maintained by thinning at three leaf stage. Phosphorus (P) and Potassium (K) were applied at sowing time at the rate of 100 kg ha^{-1} each in the form of SSP and SOP, respectively and nitrogen was applied at the rate of 150 kg ha^{-1} at different growth stages in the form of Urea.

Table 1. Soil physical and chemical analysis.

Characteristic	Unit	Value	
A. Particle size distribution		**2008**	**2009**
Sand	%	58	60
Silt	%	20.2	18
Clay	%	21.8	22
Textural Class	-	Sandy clay loam	Sandy clay loam
Saturation %age	%	32	31
B. Chemical analysis			
EC	dS/m	1.42	1.54
pH	-	7.9	8.0
Organic Matter	%	0.72	0.69
Organic Carbon	%	0.42	0.40
Total Nitrogen	%	0.042	0.035
Available P	ppm	6.1	6.8
Available K	ppm	120	115

A plant density of 66,667 plants ha^{-1} was maintained in all the treatments. In addition to rainfall received during the whole crop season, a total of five irrigations were applied to maize each of 7.5 cm depth. First irrigation was applied 25 days after crop sowing, while subsequent irrigations were applied with 15 days interval. Weeds were controlled by hoeing done at 30 days after crop sowing. Furadan 3G was applied to control maize stem borer.

Data for different agronomic parameters was collected to find out the best treatment. Ten cobs from each subplot were collected at physiological maturity and number of grain rows, number of grains and grain weight were measured and then averaged to find out grains per cob, grain rows per cob and grains weight per cob. 1000-grains were counted from the grains of cobs of each subplot threshed and weighed to find out 1000-grain weight. Two central rows were harvested at maturity from each subplot to find out grain yield in kg per plot and then converted to t ha^{-1}.

***Statistical analysis*:** The data collected were statistically analyzed using computer software MSTAT-C (Freed and Scott, 1986). Analysis of variance technique was used to test the data and LSD at 0.05 probability level was used to compare the treatment's means (Steel *et al.,* 1997).

RESULTS

***Cob length (cm)*:** Tillage treatments had a slight but significant effect on cob length of maize in 2008 while non-significant in 2009. Cob length was more for the conventional tillage in comparison with chisel plough and mould board plough (Table 2). A significant effect of nitrogen application timing was found in 2008, while in 2009 the effect was non-significant. Maize produced cobs of smaller length when N was applied in two splits i.e. ½ at sowing + ½ at knee height during 2008 (Table 2). The significant year effect was found with significantly larger cobs in 2009 as compared to 2008. The tillage by nitrogen application timing interactive effect was found significant for both years. Conventional tillage along with nitrogen application at sowing and tasseling produced larger cobs compared with other treatments. Significantly ($p \leq 0.05$) smaller cobs were observed when maize was grown with mould board plough by nitrogen application in 3 splits i.e. $^{1}/_{3}$ at sowing + $^{1}/_{3}$ at knee height + $^{1}/_{3}$ at tasseling in 2008. In 2009 larger cobs were observed in maize plots tilled with chisel plough where nitrogen was applied in three splits while smaller cobs were observed in maize plots prepared with chisel plough along with N application in 2-splits i.e. ½ at sowing + ½ at tasseling (Table 4).

***Number of grains per cob*:** Tillage with different implements significantly affected grains per cob. Chisel tilled plots produced 2.35% and 7.14% higher grains number per cob compared with conventional tillage and mould board plough respectively, during 2008. Similar trend was observed during 2009. Significantly ($p \leq 0.05$) more grains per cob was recorded in chisel plough in both years but was statistically similar to conventional tillage during second year of study with lesser grains per cob under mould board ploughed plots (Table 2). Split application of nitrogen at different growth stages had no effect on grains per cob during first year of

Table 2. Impact of tillage and time of nitrogen application on cob length, number of grains per cob and grain rows per cob in maize during 2008 and 2009.

Treatments	Cob length (cm)		No. of grains per cob		Grain rows per cob	
Tillage	2008	2009	2008	2009	2008	2009
T_1	17.61a ± 0.18	20.28 ± 0.19	469.37b ± 6.98	427.70a ± 6.29	15.76 ± 0.20	15.82 ± 0.26
T_2	16.43b ± 0.26	19.98 ± 0.17	446.40c ± 7.63	403.85b ± 12.12	15.51 ± 0.20	15.46 ± 0.23
T_3	16.47b ± 0.15	20.16 ± 0.29	480.72a ± 8.65	441.35a ± 9.28	15.96 ± 0.19	16.00 ± 0.21
LSD ($p \leq 0.05$)	0.796	NS	10.43	18.08	NS	NS
Nitrogen timings (N)						
N_1	16.93 a ± 0.22	20.03 ± 0.26	462.13 ± 14.4	403.63 b ± 16.93	15.63a ± 0.27	16.29 a ± 0.31
N_2	16.34 b ± 0.21	20.29 ± 0.22	466.82 ± 8.10	414.78 b ± 12.06	15.96a ± 0.20	16.00 a ± 0.27
N_3	17.10 a ± 0.38	20.01 ± 0.34	477.78 ± 10.38	432.83ab ± 11.39	16.07a ± 0.21	15.77ab ± 0.22
N_4	17.04 a ± 0.33	19.89 ± 0.24	451.72 ± 13.49	416.85 b ± 11.55	14.96b ± 0.23	15.18 b ± 0.36
N_5	16.76ab± 0.39	20.48 ± 0.36	469.04 ± 9.00	453.42 a ± 07.96	16.07a ± 0.21	15.55ab ± 0.22
LSD ($p \leq 0.05$)	0.51	NS	NS	27.12	0.57	0.74
(T×N)	*	*	NS	*	NS	NS

Means not sharing the same letters differ significantly at $p \leq 0.05$, NS= not significant

T_1: Conventional Tillage (2-Cultivation), T_2: Tillage with mould board plough + 2-Cultivation, T_3: Tillage with Chisel plough +2-Cultivation, N_1: Whole at sowing, N_2: ½ at sowing + ½ at V_5, N_3: ½ at sowing + ½ at tasseling, N_4: ½ at V_5+ ½ at tasseling, N_5: $^{1}/_{3}$ at sowing + $^{1}/_{3}$ V_5 + $^{1}/_{3}$ at tasseling

Table 3. Impact of tillage and time of nitrogen application on grains weight per cob, 1000-grain weight and grain yield in maize during 2008 and 2009.

Treatments	Grains weight per cob (g)		1000-grain weight (g)		Grain yield (t ha^{-1})	
Tillage	2008	2009	2008	2009	2008	2009
T_1	120.76 b ± 3.48	126.33ab ± 2.85	264.26ab ± 3.58	299.76ab ± 4.07	5.63 b ± 0.12	6.58b ± 0.21
T_2	109.18 c ± 2.73	115.30 b ± 3.91	250.45 b ± 2.63	289.27 b ± 4.01	5.16 c ± 0.10	5.73c ± 0.14
T_3	127.65 a ± 3.43	134.45 a ± 3.66	272.18 a ± 3.33	306.40 a ± 3.08	6.30 a ± 0.11	7.04a ± 0.13
LSD ($p \leq 0.05$)	6.59	14.12	14.20	11.95	0.10	0.27
Nitrogen timings (N)						
N_1	116.78ab ± 3.86	118.39 b ± 5.46	257.25 b ± 4.40	294.35ab ± 3.63	5.40c ± 0.23	6.33b ± 0.20
N_2	118.05ab ± 4.76	120.63 b ± 4.27	260.22ab ± 4.67	299.37ab ± 3.62	5.64b ± 0.22	6.36b ± 0.24
N_3	124.15 a ± 4.40	131.18 a ± 3.92	266.74ab ± 4.88	304.07 a ± 5.01	5.96a ± 0.25	6.58b ± 0.24
N_4	112.65 b ± 4.79	116.75 b ± 4.19	255.19 b ± 4.36	286.41 b ± 5.68	5.35c ± 0.27	6.00c ± 0.47
N_5	124.36 a ± 5.61	139.83 a ± 4.05	272.09 a ± 5.64	308.19 a ± 5.84	6.13a ± 0.34	6.97a ± 0.18
LSD ($p \leq 0.05$)	8.32	9.74	11.75	12.98	0.18	0.27
(T×N)	NS	NS	NS	NS	*	NS

Means not sharing the same letters differ significantly at $p \leq 0.05$, NS= not significant

T_1: Conventional Tillage (2-Cultivation), T_2: Tillage with mould board plough + 2-Cultivation, T_3: Tillage with Chisel plough +2-Cultivation, N_1: Whole at sowing, N_2: ½ at sowing + ½ at V_5, N_3: ½ at sowing + ½ at tasseling, N_4: ½ at V_5+ ½ at tasseling, N_5: $^1/_3$ at sowing + $^1/_3$ V_5 + $^1/_3$ at tasseling

Table 4. Impact of year on number of grains per cob, grain rows per cob, grains weight per cob, 1000-grain weight and grain yield in maize during 2008 and 2009.

Year	Cob length (cm)	No. of grains per cob	Grain rows per cob	Grains weight per cob (g)	1000-grain weight (g)	Grain yield (Mg ha^{-1})
2008	16.84b	465.5 a	15.74	119.2 b	262.3 b	5.70 b
2009	20.14a	424.3 b	15.76	125.4 a	298.5 a	6.45 a
LSD ($p \leq 0.05$)	0.42	7.08	NS	5.28	6.29	0.10

Means not sharing the same letters differ significantly at $p \leq 0.05$, NS= not significant

study. However, during second year, it had significant effect on grains number per cob. The maximum grains per cob were produced by the maize grown once nitrogen was applied in three splits (N_3) ($^1/_3$ at sowing + $^1/_3$ at V_5 + $^1/_3$ at tasseling), however, statistically similar with plots where nitrogen applied in two splits (½ at sowing + ½ at tasseling). Tillage and nitrogen timing interaction (N × T) found significant in 2009, while non-significant during 2008. Significantly higher grains number recorded in case of chisel tilled plots where nitrogen was applied in three splits while lesser grains number was recorded in mould board tilled plots where half of nitrogen applied at sowing and half at V_5 (Fig. 2). Year also significantly affected the grains per cob. Statistically highest grains per cob were recorded during 2008 while significantly lowest grains per cob were recorded during 2009 (Table 4).

***Grain rows per cob*:** Grain rows per cob in maize did not differ significantly under different tillage treatments but differed significantly by nitrogen application at different growth stages during both years. Nitrogen application at 5-leaf stage (V_5) and tasseling produced lesser grain rows per cob while remaining treatments produced more grain rows per cob in 2008. Similar results were observed in 2009 (Table 2). Year had no significant effect on grain rows per cob (Table 4). A non-significant interaction effect between tillage and nitrogen application timing was found for grain rows per cob.

***Grains weight per cob (g)*:** Grains weight per cob was significantly affected when maize was grown under different tillage regimes. Maximum grains weight per cob (127.6) was observed in case of chisel ploughed plots and minimum was obtained from maize plots treated with mould board plough during both study years while it was found at par with plots cultivated by conventional methods during second year. Time of nitrogen application had significant effect on grains weight per cob. Nitrogen application to maize in three splits produced heavier cobs which were at par with other treatments except N_4 where ½ of nitrogen was applied at V_5 stage and remaining half dose was applied at tasseling stage in 2008. In 2009 maize plots fertilized with nitrogen in three splits produced heavier cobs which were at par with the maize plots received nitrogen in two splits i.e. ½ at sowing and ½ at tasseling stage. Significantly the lowest grains weight per cob was observed in plots where nitrogen was applied in two splits i.e. ½ at V_5 and ½ at tasseling stage (Table 3). Year had significant effect on grains weight and significantly the heavier cobs were noted in 2009, while the lighter cobs were noted in 2008 (Table 4). A non-significant interaction effect between tillage practices and time of nitrogen application was observed regarding grains weight per cob in both study years.

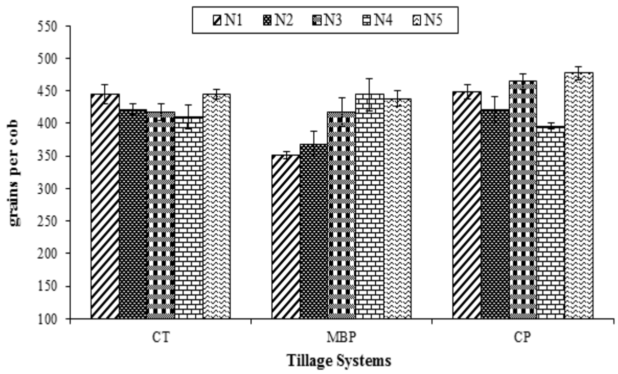

Figure 2. Interactive effect of tillage and nitrogen timings on grains per cob.

1000-grain weight (g)**:** Different tillage practices and time of N application had pronounced effect on maize 1000-grain weight. Maize grown in chisel tilled plots produced heavier grains and was at par with conventionally grown maize while lesser 1000-grain weight under mould-board treated plots during both years. The highest 1000-grain weight was observed in maize plots where nitrogen was applied in 3-splits at different growth stages and was at par with N_3 and N_2. However, lesser thousand grains weight was observed in maize plots treated with nitrogen application in two splits i.e. ½ at V_5 and ½ at tasseling during both study years (Table 3). Year also had a substantial impact on 1000-grain weight and heavier grains were observed in second year as compared to first one (Table 4). Tillage by nitrogen timing interaction remained unaffected.

Grain yield (t ha^{-1})**:** Data indicated a significant effect of different tillage systems and time of N application on grain yield (Table 3). The highest grain yield was recorded in chisel tilled plots while lowest grain yield was recorded in mould-board ploughed plots during both years of study (Table 3). Moreover, highest yield was observed in plots where nitrogen was applied in 3 splits i.e. $^1/_3$ at sowing + $^1/_3$ at V_5 + $^1/_3$ at tasseling during both years but was at par with N_3 (½ at sowing + ½ at tasseling) only during first year. However, the lowest grain yield was recorded in maize plots where nitrogen was applied in two splits i.e. ½ at V_5 and half at tasseling during both years with slight increment in second year compared with first one. The tillage by nitrogen application timing interaction was found non-significant in 2009 while significant ($p \leq 0.05$) in 2008 (Fig. 3). Grain yield with nitrogen application in three splits was greater with chisel plough compared with other tillage systems. However, lower grain yield was observed with nitrogen application in two splits (½ at V_5 + ½ at tasseling) with mould board plough treated plots. The combined analysis of the data showed that year had significant ($p \leq 0.05$) effect on maize grain yield and significantly ($p \leq 0.05$) higher grain yield was obtained in 2009 while lower grain yield was obtained in 2008 (Table 4).

Table 5. Interactive effect of different tillage systems and time of nitrogen application on cob length (cm) in maize.

Treatments	Tillage		
Nitrogen Levels	T_1	T_2	T_3
	2008		
N_1	17.20 abc *	17.33 ab	16.27 cde
N_2	16.67 bcd	16.60 bcd	15.77 de
N_3	18.17 a	16.93 bc	16.20 cde
N_4	18.03 a	15.90 de	17.20 abc
N_5	17.97 a	15.40 e	16.90 bc
LSD (5%)		0.88	
	2009		
N_1	19.89 b-e *	19.77 cde	20.44 a-d
N_2	21.00 ab	19.44 de	20.44 a-d
N_3	20.66 abc	20.47 a-d	18.89 e
N_4	20.44 a-d	19.72 cde	19.50 de
N_5	19.38 de	20.50 a-d	21.55 a
LSD (5%)		0.99	

*Means not sharing the same letters in the column differ significantly at $p \leq 0.05$

T_1: Conventional Tillage (2-Cultivation), T_2: Tillage with mould board plough + 2-Cultivation, T_3: Tillage with Chisel plough +2-Cultivation, N_1: Whole at sowing, N_2: ½ at sowing + ½ at V_5, N_3: ½ at sowing + ½ at tasseling, N_4: ½ at V_5+ ½ at tasseling, N_5: $^1/_3$ at sowing + $^1/_3$ V_5 + $^1/_3$ at tasseling

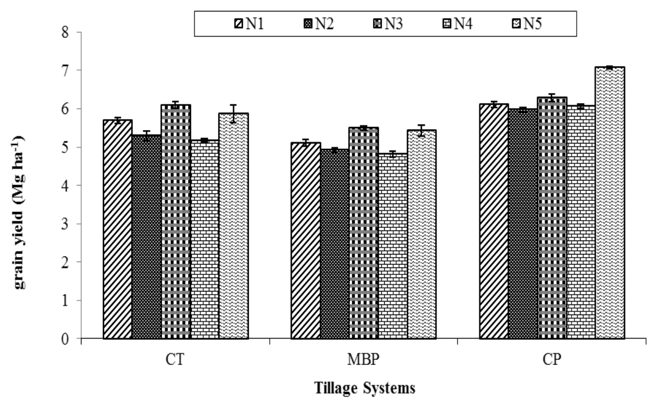

Figure 3. Interactive effect of tillage and nitrogen timings on maize grain yield (t ha^{-1}).

Correlation coefficient among different yield parameters was drawn which showed a positive and significant relationship of grains weight cob^{-1} with 1000-grain weight, grains cob^{-1} and grain yield. Similarly a positive and significant relationship of 1000-grain weight with grain yield was found during 2008 (Table 6). During 2009 a positive relationship of grains weight cob^{-1} with grains cob^{-1} and grain yield and a significant

Table 6. Correlation coefficient among number of grains per cob, grain rows per cob, grains weight per cob, 1000-grain weight and grain yield in maize during 2008.

Parameters	Cob length	Rows cob^{-1}	Grains weight cob^{-1}	1000-grain weight	Grains cob^{-1}
Rows cob^{-1}	0.1129				
Grains weight cob^{-1}	0.1260	0.4651			
1000-grain weight	0.1306	0.2739	0.6376*		
Grains cob^{-1}	-0.0409	0.3485	0.6179*	0.1569	
Grain yield	0.0101	0.4477	0.7666*	0.6585*	0.4315

Table 7. Correlation coefficient among number of grains per cob, grain rows per cob, grains weight per cob, 1000-grain weight and grain yield in maize during 2009.

Parameters	Cob length	Rows cob^{-1}	Grains weight cob^{-1}	1000-grain weight	Grains cob^{-1}
Rows cob^{-1}	0.0431				
Grains weight cob^{-1}	0.2909	-0.0011			
1000-grain weight	0.0515	-0.0098	0.4970		
Grains cob^{-1}	0.2242	-0.1274	0.6888*	0.1267	
Grain yield	0.1200	0.1981	0.7006*	0.5760*	0.4525

and positive relationship of 1000-grain weight with grain yield were found (Table 7).

DISCUSSION

Tillage and nutrient management especially the N are the key factors to affect crop yield including maize (Shi *et al.*, 2016; Wasaya *et al.*, 2017). Deeply ploughing the soil may lead to lower soil bulk density and results in improved crop yield (Chatterjee and Lal, 2009; Cai *et al.*, 2014). In the current study, less number of grains per cob was observed in mould board ploughed plots which might be due to high soil bulk density which decreases the root penetration to a deeper soil layer (Ahadiyat and Ranamukhaarachchi, 2008). Similarly, heavier and healthier grains was observed in chisel ploughed plots which may be attributed to well prepared seedbed which gave better environment to plant roots and ultimately resulted to healthy cobs and improved the 1000-grain weight as well as grain yield (Diaz-Zorita, 2000; Wasaya *et al.*, 2011; Wasaya *et al.*, 2017). Heavier thousand grain weight under chisel plough may be attributed to sufficient water availability in tilled plots which facilitated proper translocation of photosynthates resulting in good grain filling and ultimately produced healthy grains that resulted to higher 1000-grain weight (Gurumurthy *et al.*, 2008). Similarly, higher grain yield with chisel plough is obtained as a result of more grains weight per cob and 1000-grain weight, which might be due to higher leaf area index (LAI) and crop growth rate (CGR) (Wasaya *et al.*, 2017). This gain in maize yield under chisel plough might be due to deeper penetration of maize roots which extracted more nutrients and water from the deeper soil layer and produced higher yield (Diaz-Zorita, 2000; Wasaya *et al.*, 2011; Iqbal *et al.*, 2013).

Nitrogen is an important major plant nutrient and plays a significant role in improving crop yield especially when applied in different splits (ViswaKumar *et al.*, 2008; Sitthaphanit *et al.*, 2010). In current study, it was observed that increasing nitrogen splits resulted to prolong maize reproductive growth period which led to more partitioning of photo-assimilates to grains during grain filling period and improved grains number per cob (Amanullah *et al.*, 2009b). This increase in grain number might also be due to more grain rows per cob. However, increase in grain rows per cob under split application of nitrogen might be due to availability of nitrogen at grain formation stages and had positive effect on grain rows. These results are in line with those observed by Harikrishna *et al.* (2005), who reported an increase in grain rows per cob by increasing number of nitrogen splits and obtained the highest grain rows per cob with nitrogen application in four splits. This increase in grain number as well as grain rows per cob under split application of N favoured the grain weight per cob as well 1000-grain weight and grain yield. The increase in grain weight per cob and 1000-grain weight might be ascribed to improved vegetative and reproductive growth due to split application upto silking (Amanullah *et al.*, 2009b) because N application at later stages i.e. upto silking resulted to more photosynthesis and translocation of photo assimilates to grains (Akbar *et al.*, 1999), and hence improved grains weight per cob. These results are also in conformity with the findings of Abdin *et al.* (1996), who reported an increase in grains weight per cob by applying nitrogen in more than two splits. Nitrogen application at later growth stages resulted to higher nitrogen uptake, led to high source: sink ratio during grain filling and increased dry matter accumulation (Rajcan and Tollenaa, 1999), which might be resulted to higher 1000-grain weight. Higher 1000-grain weight with increasing number of nitrogen splits was also reported by Amanullah and Shah (2010). These results are also in conformity with the findings of (Silva *et al.*, 2005), who described that grain weight in maize increases with nitrogen application at flowering stage (booting or silking). The highest 1000-grain weight in second experimental year might be attributed to even distribution of rainfall throughout the growing period of maize in second year than first experimental year.

The highest grain yield with nitrogen application in three splits might be attributed to more grains number and grains weight per cob as well as 1000-grain weight. Increased grain yield with increasing number of nitrogen splits may be due to reduction in inorganic nitrogen losses especially through leaching (Sitthaphanit *et al.,* 2009) and volatilization (ViswaKumar *et al.,* 2008). The highest grain yield with nitrogen application in three splits was also reported by Sitthaphanit *et al.* (2010). This increase in grain yield with increasing N splits might be due to more leaf area per plant (Amanullah *et al.,* 2009a). Less grain yield in N_4 may be attributed to unavailability of N at initial growth stages. These results are in accordance with the Binder *et al*. (2000), who reported 12% decrease in maize yield when N application was delayed to six-leaf stage. More grain yield during second experimental year might be attributed to occurrence of rainfall at grain filling stage which led to healthier grains and ultimately resulted in higher grain yield. A significant and positive correlation between grains weight cob^{-1} with 1000-grain weight, grains cob^{-1} and grain yield in maize was found which are similar to the results reported by Inamullah *et al*. (2011), who also observed a strong and positive correlation between 1000-grain weight, grains cob^{-1} and grain yield.

Conclusion**:** It is concluded that deep tillage with chisel plough enhances yield attributes like grains per cob, grains weight per cob and 1000-grain weight and ultimately resulted to higher grain yield. Deep tillage resulted to ameliorate the subsoil compaction and provide ideal conditions for maize roots through exploring more soil area for uptake of nutrients and resulted to healthy crop and ultimately improved the yield. Similarly, split application of nitrogen improved maize grain yield and yield related attributes. Split application of nitrogen resulted in reduction of nitrogen losses occurred in various forms like leaching and volatilization and led to better utilization of nitrogen due to its availability at stages when plant require it more as compared to nitrogen application in single dose or at planting.

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