Journal of Maize Research and Development (2015) 1(1):10-20
ISSN: 2467-9305 (Online)/ 2467-9291 (Print)
DOI: 10.5281/zenodo.34285

Tillage and planting density affect the performance of maize hybrids in Chitwan, Nepal

Tika Bahadur Karki[1*], Govind KC[1], Jiban Shrestha[1] and Jitendra P. Yadav[1]

ARTICLE INFO

Article history:
Received:
10th September, 2015 Revised:
25th October, 2015 Accepted:
15th November, 2015

Keywords:
Tillage, density, affect, maize, hybrids

ABSTRACT

To find out whether the different tillage methods at different planting densities affect the performance of maize hybrids, an experiment was carried out at National Maize Research Program, Rampur during spring season of 2013 and 2014. The experiment was laid out in strip plot design with three replications having 12 treatments. The vertical factor was tillage with conservation tillage (No Tillage + residue=NT) and conventional tillage (CT) and the horizontal factor were genotypes (Rampur Hybrid-2 and RML-32/RML-17) and in split planting geometries (75cm × 25cm =53333 plants/ha, 70cm × 25cm=57142 plant/ha and 60cm ×25cm= 66666 plants/ha). In both the years, the highest number of cobs (73,177 and 67638/ha) was recorded at planting density of 66666/ha. NT had the highest no of kernel rows/cob (14.01) as against 12.12 in CT in 2014. The highest number of kernels (27.3 and 29.29) per row was recorded in NT during 2013 and 2014 respectively. Similarly, in 2014, the highest number of kernels were found in RML-32/RMl-17 (29.17/row) and planting density of 53333/ha (28.46/row). In 2013, RML-32/RML-17 produced the highest test weight of 363.94g over the Rampur hybrid-2 with 362.17g. Significantly the highest grain yield of 9240.00 kg/ha in 2013 and 7459.80 kg/ha in 2014 at planting geometry of 65cm ×25cm were recorded. No effects was found by tillage methods for grain yields of maize in 2013, but was found in 2014 (7012.18 kg in NT compared to 6037.59 kg/ha in CT). NT and wider spaced crop matured earlier in both the years; however Rampur hybrid-2 matured earlier to RML-32/RML-17 in 2013. In 2014, harvest index of 47.85 % was recorded in planting geometry of 66666/ha, the highest benefit cost ratio of 1.36 was worked out in NT and 1.46 at the density of 66666/ha. The highest value of 2.46% of soil organic matter was recorded in NT as compared to 2.43% in CT.

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crops grown mainly during the summer season in Nepal. It is the second most important staple crops after rice both in terms of area and production. Its area, production and productivity in Nepal is 928761 ha, 2283222 Mt and 2458 Mt/ha (MOAD, 2014), respectively. It contributes 3.15% to national GDP and 9.5% to agricultural GDP (MOAD, 2013).

Corresponding author Info:
**Senior Scientist (S3), 1 .Nepal Agricultural Research Council, National Maize Research Program, Rampur, Chitwan, Nepal*
E-mail: tbkarki@nmrp.gov.np or tbkarki2003@gmail.com

Despite the many efforts made, the productivity of maize is almost stagnant or slightly decreasing (MOAD, 2013 and MOAD, 2014). The overall demand for maize driven by increased demand for human consumption and livestock feed is expected to grow by 4% to 6 % per year over the next 20 years (Paudyal *et al*., 2001). Thus, Nepal will have to resort to maize imports in the future if productivity is not increased substantially. The poor yields might be due to poor crop management technologies and poor yielding genotypes coupled with declining soil's productivity and higher production costs. Shortage of agricultural labor has further exacerbated the situation (Joshi *et al*., 2012). Therefore, there is a challenge to identify an alternative agricultural system that conserves soil and improve the fertility and also less labor and reduce the cost of production in Nepal. Conservation tillage involves no or minimum tillage with at least 30% of the crop residue must remain on the soil surface at the time of planting (CTIC, 2015), seems to be promising technology in Nepal too. Among the various biotic factors, maize yield is more affected by variations in plant density than other member of the grass family (Vega *et al*., 2001). Maize differs in its responses to plant density (Luque *et al*., 2006). Liu *et al*. (2004) also reported that maize yield differs significantly under varying plant density levels due to difference in genetic potential. Plant populations affect most growth parameters of maize even under optimal growth conditions and therefore it is considered a major factor determining the degree of competition between plants (Sangakkara *et al*., 2004). The grain yield per plant is decreased (Luque *et al*., 2006) in response to decreasing light and other environmental resources available to each plant (Ali *et al*., 2003). Very recently one maize hybrid Rampur Hybrid-2 has been released for general cultivation and another RML-32/RML-17 is under consideration for release in Nepal. Maize hybrids differ in their response to plant density (Xue *et al*., 2002). As maize does not have tillering capacity to adjust to variation in plant stand, optimum plant population for grain production is important. Unfortunately, there is no single robust recommendation for optimum plant densities, since the density varies with environmental factors such as crop establishment methods i.e. tillage, soil fertility, moisture supply, genotype (Gonzalo *et al*., 2006), planting date, planting pattern, plant population and harvest time. The differential response to plant density in maize cultivars has been reported by Xue *et al*. (2002). Nepal has developed some promising hybrids for the Terai and it is necessary to test, verify and promote them under no till condition, since conservation agriculture has been emerging as the inevitable technology to save labor cost, conserve moisture and increase yields thereby sustaining productivity. The aim of this study is to determine the optimum planting density of maize hybrids under various tillage methods in Nepal.

MATERIALS AND METHODS

Experimental site

A field experiment was conducted during spring season (February to June) of 2013 and 2014 in National Maize Research Program (NMRP) farm, Rampur, Chitwan, Nepal. The experimental site is 10 km far in South-West direction from headquarter of Chitwan district, Bharatpur. It is located at 27^{0} 37'North latitude and 84 ^{0} 25' East longitudes with an elevation of 256 meter above mean sea level. Experimental soil was sandy-loam in texture with 2.47% of organic matter, 0.13% of total nitrogen, 51.0 and 109.5 kg/ha respectively of available phosphorus and potassium. The experimental site falls under the subtropical humid climate belt of Nepal which is characterized by three different seasons that prevail in the experimental site: cool winter (November to February), hot spring (March to May), and distinct rainy monsoon season (June to October). The maximum and minimum temperature, relative humidity and rainfall were the weather parameters recorded during crop season of spring 2013 and 2014 (Fig 1 and 2).

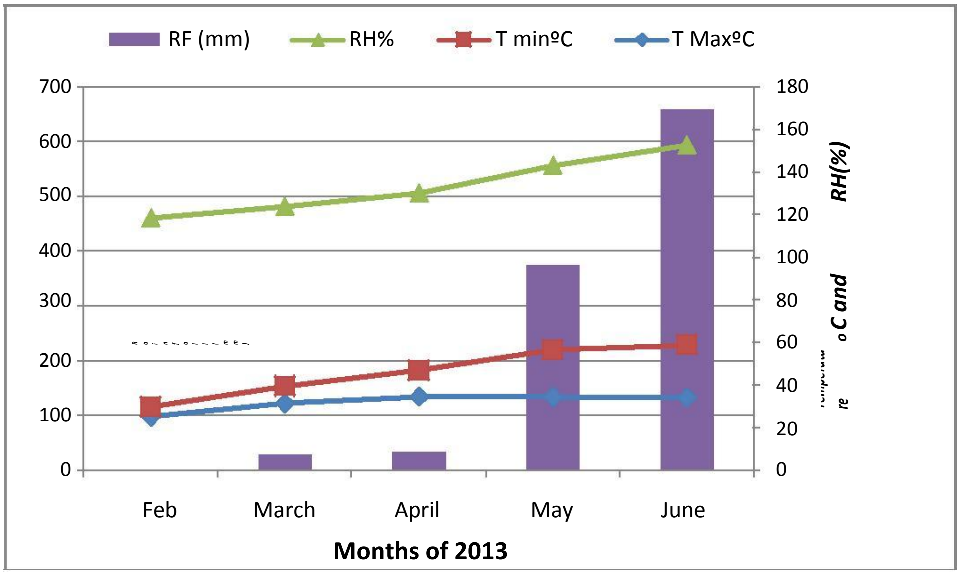

Fig 1. Maximum and minimum temperatures (°c), relative humidity (%) and rainfall (mm), 2013

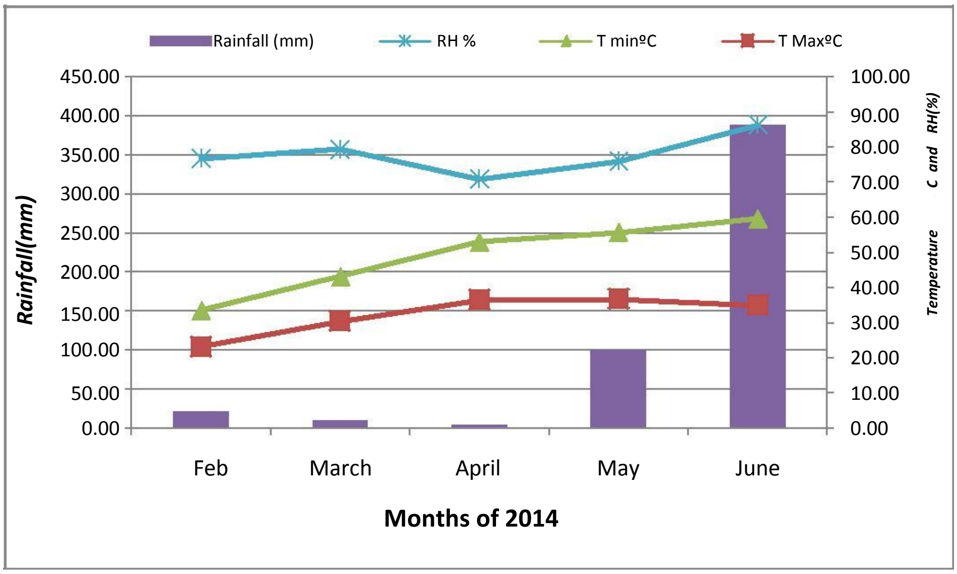

Fig 2. Maximum and minimum temperatures (°c), relative humidity (%) and rainfall (mm), 2014

Experimental setup

The experiment was planted during winter season of 2013 and 2014 and the field was laid out in strip plot design with three replications and 12 treatments. The vertical factor was tillage with conservation tillage (no till + crop residue=NT) and conventional tillage (CT) and the horizontal factor were genotypes (Rampur Hybrid-2 and RML-32/RML-17) and in split planting geometries (75cm × 25cm =53333 plants/ha, 70cm × 25cm=57142 plants/ha and 60cm × 25cm= 66666 plants/ ha). The individual plot size was having 7 rows of 5 meter long as prescribed by the treatments. The three central rows were used as net plot rows for biometric and agronomical data recording and the remaining 2 rows leaving the two border rows at either side were used for biometrical and phenological observations. Maize crop was planted on 12th and 15th of February and harvested on 27th and 26th of June, 2013 and 2014 respectively. The crop was fertilized with 120:60:40 kg $NP_2O_5K_2O$/ha. Fifty % of the N along with full P and K was applied during seeding and remaining N was splitted into 2 and first half was applied at V7 stage and and the remaining N at pre-tasseling stage of maize. Rest of the crop management operations were done as per the treatment. Weather parameters were recorded from the NMRP's meteorological station. Soil texture, bulk density, organic matter content, pH, total N, available P and K were analyzed using the prescribed laboratory procedures. Cob diameter, no of cobs/ha, no of kernel rows/cob, no of kernels/row, thousand grain weight (g), grain and stover yield (Mg/ha) and economics analysis were measured. Economics of the tested treatments was also worked out. The collected data was processed by MS Excel and analyzed by using ANOVA method of strip-split plot design in GENSTAT Discovery version.

RESULTS AND DISCUSSION

No of plants and cobs per hectare

Tillage methods and genotypes did not affect the no of plants per hectare, however was affected by different plant densities in 2013 and 2014 (Table1 and 3). Planting geometries of 65cm between rows and 25 cm between plants produced the highest number of cobs 67638/ha followed by 57291/ha in spacing of 70×25cm and 53472 in 75×25 cm (Table 1). Similar was the findings of Wang et al. (2015), they also reported that tillage methods did not affect the number of plants and ears per unit area. Similarly, the number of ears per plant was significantly affected by different plant population densities as found by Abuzar et al. (2011).

Plant height of maize

Significant effects of tillage and planting geometries on plant height of maize was observed in 2014. Conventional tillage had the highest plant height of 200.93 cm as against 182.17 cm in NT. The difference between the tested hybrids for plant height was not evident this year. Interestingly, the planting geometries affected the plant height of maize. Higher value of it was recorded in closely spaced plantings than widely spaced planting. Planting spacing of 65×25 cm had the highest plant height of 202.64 cm followed by 189.71cm in 70×25 cm and 182.29 cm and in 75×25 cm (Table 1). Use of high populations heightens interplant competition for light, water and nutrients. When plants are closely spaced, the increased shading effect of the bottom of the plants accelerates the plant growth. A single plant standing by itself dose not grows as fast or grows as tall as plants in a dense population (NDSU, 1999). Sangoi and Salvador (1997) revealed from an experiment with different genotypes and plant densities that height of the plant was significantly influenced by the plant density. Averaged of all cultivars, each increase in 25, 000 plants ha-1 promoted an increase of 2.7 cm in plant height. Mashiqa et al. (2011) found that the plant height was more in higher densities than lower densities, however the plant height was found non-significant due to tillage methods.

Ear height of maize

Unlike the plant height, ear height was not affected by tillage methods revealing the more or less uniform placement of ears. However, the height was higher of 116.86 cm in Rampur hybrid-2 compared to 111.36 cm in RML-32/RML-17. Planting geometries of 65×25 cm had the highest ear height of 116.04 cm followed by 114.6 cm in 70×25 cm and 111.63 cm in 75×25 cm (Table 1).

Cob diameter and length

Significant variation on cob diameter was observed due to tillage, genotypes and planting geometries in 2014. Higher cob diameter of 4.16 was recorded in CT compared to 3.89 cm in NT. Rampur hybrid-2 had the higher diameter of cob compared to RML-32/RML-17. Similarly, the value was more in wider spaced plantings than closely spaced plantings. Similar results were found for cob length due to different hybrids (Table 1). Mashiqa et al. (2011) however found that the cob length and diameter were more in lower plant densities.

Physiological maturity

Crop duration was affected significantly by tillage and planting geometry. Crop from NT matured earlier at 131 days than CT at 136 days. Likewise, wider spaced crop matured earlier than the closed spaced and the crop planted at planting geometry of 75 cm between rows and 25 cm between plants matured earlier at 132 days followed by 133 days in 70×25 cm and 135 days in 65×25 cm spacing (Table 1). Similar was the findings of Araus *et al*. (2008). Correspondingly, in 2014, crop duration was affected significantly by tillage, genotypes and planting geometry. Irrespective of genotypes and planting geometry, crop from NT matured earlier at 130.7 days than CT at 133.8 days. As far as genotypes are concerned, Rampur hybrid-2 took 131.78 days and RML-32/RML-17 matured at 132.78 days. Wider spaced crop matured earlier than the closed spaced and the crop planted at planting geometry of 75cm between rows matured earlier at 130.83 days followed by spacing of 70×25 cm with 132.42 days. The longest duration of 133.58 days was recorded in 60×25cm (Fig 3). Similar results were found by Amanullah *et al*. (2009) and reported that physiological maturity was delayed in those plots maintained at higher plant density. This suggests that dense planting might have slightly slowed down the rate of plant development because of more competition in dense population (Hamid and Nasab, 2001).

Number of kernel rows/cob

Number of kernel rows/cob varied due to tillage methods but not by different planting geometries and genotypes. NT had the higher (14.01) no of kernel rows per cob as against the 12.12 in CT (Table 2). In the past year, number of kernel rows/cob did not vary due to tillage, genotypes and planting geometry. Both the methods of tillage (NT and CT) produced the similar number of kernel rows in a cob. It might be due to the similar availability of soil moisture, nutrients and solar radiation for photosynthesis. However, the rows were more in CT plot and planting geometry of 75cm between rows and 25cm between plants. The two hybrids Rampur Hybrid-2 and RML-32/RML-17 were having the same number of kernel rows in a cob (Table 3).

Number of kernels/row

Differences due to various tillage methods, genotypes and planting geometry were evident for the number of kernels/row. Significantly the highest number of kernels per row was recorded in NT (29.29) over CT (25.911), RML-32/RMl-17 (29.17) against Rampur hybrid-2 (26.02) and in 75×25 cm spacing (28.46) (Table 2). Similarly, the difference due to genotypic and planting geometry was not evident for the number of kernels/ row. Last year, significantly the highest number of kernels per row was recorded at the planting geometry of 60cm between rows and 25cm between plants. Tillage methods affected it and were higher of 27.3 rows in NT as against the 25.8 in CT (Table 3). Similar findings were also reported by Sornpoon and

Jayasuriya (2013), where they did not found any difference in number of kernels per row of maize.

Thousand grain weight

Except planting geometry, differences were observed non significant due to tillage and genotypes on the thousand grain weight of maize. Cropping geometry of 75×25cm produced the highest value of it (285.61g). Thus the higher thousand grain weight was observed in wider spaced than closely spaced planting (Table 2). During the year 2013, except genotypes, no differences were observed due to tillage and planting geometry on the thousand grains weight of maize. But, RML-32/RML-17 produced the highest test weight of 363.94 g over the Rampur hybrid-2 with 362.17g. However, NT had higher test weight to CT. Similarly, slightly a higher test weight was observed in wider spaced planting than closely spaced (Table 3). Shahzad *et al.* (2015) reported that thousand grain weights decreased with increasing planting density. Maximum thousand grain weight of 253 g was recorded from lowest plant density of 65000 plants/ha which is at par with 80000 plants/ha with thousand grain weight of 250 g. Minimum thousand grain weight of 242 g was recorded from the highest planting density of 95000 plants/ha.

Grain yield

Grain yield of maize was significantly affected by tillage and planting geometry. Genotypic differences between the hybrids (Rampur Hybrid-2 and RML-32/RML-17) were not observed. The highest grain yield of 7012.18 kg/ha was harvested from NT as against the 6037.59 kg/ha in CT. Similarly, planting at 65×25 cm spacing produced the highest grain yield of 7459.80 kg/ha over 75 × 25cm with 6080. 91 kg/ha (Table 2). Likewise, the variation in grain yield was evident due to planting geometry and was significantly higher (9.24 Mg/ha) in planting geometry of 60cm between rows and 25cm between plants in the year 2013 (Table 3). It is mainly due to the higher number of cobs per hectare in the aforementioned planting geometry. Board *et al.* (1992) observed greater light interception in the narrow row culture (0.5 m) compared to the wide row culture (1 m). They noted that this occurred during vegetative and early reproductive periods of plant growth. Similarly, Zhang *et al.* (2008) noted that the best distribution of light is attained in systems with narrow strips and high plant densities. Increasing plant density through narrow row planting of maize could increase light interception and consequently increase grain yield. Just like other resources, nitrogen (N) uptake seems to be closely related to plant spacing.

Stover yield

Stover yield of maize was also significantly affected by tillage and cropping geometry. Genotypic differences among both the hybrids Rampur Hybrid-2 and RML-32/RML-17 were not observed. The highest Stover yield of 7863.95 kg/ha was harvested from NT as against 6879.58 kg/ha in CT. Similarly, planting at 65×25 cm spacing produced the highest grain yield of 8125.41 kg/ha over 70 ×25cm with 6888.30kg/ha in 2014 (Table 2).

Harvest Index

Similar to grain yield, harvest index (HI) was also significantly varied due to tillage and planting geometries during the year 2014. The highest Stover value of 47 % was derived in NT as against 46% in CT. Similarly, planting at 65×25 cm spacing produced the highest HI of 47.85 % over 65 x 25cm with 46.07 %. However, the variation was not evident due to tested hybrids for the stated trait (Table 2). Variations in grain yield can be attributed predominantly to variations in kernel number. In a study of four maize hybrids grown at plant densities ranging from 0.5 to 24 plants/m^2, grain yield ranged from 241 to 22 g/plant ; 87% of the

variation in grain yield per plant at the two plant density extremes was attributable to variation in kernel number, as kernel weight only ranged from 278 to 188 mg kernel 1 (Tollenaar et al., 2000a). Hence, harvest index is mainly a function of the number of kernels (per plant or per m^2) during the grain filling period.

Table 1. Effect of tillage, hybrids and planning densities on the crop performance of spring maize, Rampur, 2014

Treatment	No of plants /ha	No of cobs /ha	Plant height (cm)	Ear height (cm)	Cob diameter (cm)	Cob length (cm)	Physiological maturity (days)
Tillage methods							
CT	58379	59351	200.93	113.64	4.16	15.57	135.78
NT	58425	59583	182.17	114.58	3.89	13.92	131.94
F-test	NS	NS	*	NS	***	*	**
$LSD_{0.05}$	-	-	18.55	-	0.12	0.75	0.500
Hybrids							
Rampur hybrid-2	58518	59675	194.04	116.86	4.10	14.59	133.78
RML-32/RML-17	58287	59259	189.06	111.36	3.95	14.91	133.94
F-test	NS	NS	NS	**	*	NS	NS
$LSD_{0.05}$	-		-	4.28	0.12	-	-
Plant densities							
D1	65972	67638	202.64	116.04	3.96	14.70	135.25
D2	56180	57291	189.71	114.67	4.05	14.16	133.50
D3	53055	53472	182.29	111.63	4.07	15.38	132.83
F-test	***	**	**	**	**	**	**
$LSD_{0.05}$	557.2	733.90	18.55	4.28	0.12	0.48	0.500
CV,%	1.40	1.80	14.10	5.40	4.20	7.40	3.5
Grand mean	58402	59467	191.55	114.11	4.03	14.75	133.86

Note: NT=No Tillage, CT=Conventional Tillage, D1=60×25cm, D2=70×25cm, D3=75×25cm

Economic analysis

Irrespective of tillage and genotypes, the highest net return of NRs, 51032.22/ha was worked out in planting geometry of 60×5cm followed by 20184.74/ha in 75×25cm and NRs.19045.18/ha in 70×25cm. Rampur hybrid-2 recorded the highest value of net return NRs.32452.64/ha over RML-32/RML-17 with NRs. 27722.12 per hectare (Table 3). ANOVA revealed that the higher benefit cost ratio (BC) ratio of 1.36 was worked out in NT as compared to 1.18 in CT. Among the planting geometries, planting at 60 cm between rows and 25 cm between plants produced the highest 1.46 BC ratio as compared to 1.19 in 75×25cm and. 1.16 in 70×25cm spacing in 2014 (Table 2 and 3). Bisht et al. (2012) also reported the similar results and the found in Pantnagar that higher net return from the higher plant densities.

Soil properties

The experiment has been carried-out since 2012 winter season and completed the three seasons. Soil pH was found to be not affected by different tillage methods, genotypes and planting densities. Unlike the soil pH, soil organic matter was found to be affected by tillage methods. The highest value of soil organic matter (2.46%) was recorded in NT as compared to 2.43% in CT (Table 5).

CONCLUSION

To sum up, planting geometry of 65 cm between rows and 25cm between plants having 66666 plants/ ha performed better in terms of grain yields and economics compared to the recommended density of 53333 plants/ha. Of the two hybrids, RML-32/RML-17 was found to be superior in terms of grain yield and related parameters in contrast to Rampur hybrid-2. Planting of maize in no tilled field with the previous crop's residue (maize stover) kept on the soil surface increased the soils' organic matter content over conventional tillage practice. The future plausible studies need to be concentrated on physiological basis of differential planting geometries on crop performance of maize hybrids developed by NMRP.

Table 2. Effect of tillage, hybrids and planting densities on the crop performance of spring maize, Rampur, 2014

Treatment	NKR/Cob	NK/row	TGW (g)	Grain yield (kg/ha)	Stover yield (kg/ha)	HI (%)	BCR
Tillage methods							
CT	12.12	25.91	284.57	6037.59	6879.58	46.60	1.18
NT	14.01	29.29	283.73	7012.18	7863.95	47.07	1.36
F-test	**	**	NS	**	*	*	*
$LSD_{0.05}$	0.51	1.71	-	281.60	576.8	0.29	0.11
Hybrids							
RH-2	14.31	26.02	284.51	6630.12	7471.99	46.88	1.29
RML-32/RML-17	14.00	29.17	283.78	6419.65	7271.53	46.79	1.25
F-test	NS	**	NS	NS	NS	NS	NS
$LSD_{0.05}$	-	1.71	-	-	-	-	-
Plant densities							
D1	14.08	27.79	283.16	7459.80	8125.41	47.85	1.46
D2	14.07	26.54	283.67	6033.96	6888.30	46.58	1.16
D3	14.05	28.46	285.61	6080.91	7101.58	46.07	1.18
F-test	NS	**	**	**	***	**	**
$LSD_{0.05}$	-	1.71	1.33	281.60	576.8	0.29	0.11
CV,%	5.30	9.00	7.2	12.90	11.40	0.90	12.5
Grand mean	14.07	27.60	284.15	6524.89	7371.76	46.83	1.27

Note: NK=no of Kernel, NKR=No of Kernel Rows, TGW= Thousand Grain Weight, BCR=Benefit Cost Ratio, NT=No Tillage, CT=Conventional Tillage, D1=60×25cm, D2=70×25cm, D3=75×25cm

Table 3. Grain yield and related parameters of two hybrids Rampur Hybrid-2 and RML-32/RML-17 under various tillage methods and planting geometries in Rampur, during spring, 2013

Treatments	No of cobs/ ha	NKR/Cob	NK/row	TGW (g)	Grain yield (Mg/ha)
Tillage methods					
CT	62120	14	25.8	362.5	8.35
NT	64962	13.7	27.3	363.61	8.36
F-test	*	NS	*	NS	NS
$LSD_{0.05}$	1831.1	-	1.06	-	-
Hybrids					
Rampur Hybrid-2	64205	13.8	26.4	362.17	8.32
RML-32/RML-17	62876	13.8	26.7	363.94	8.39
F-test	NS	NS	NS	*	NS
$LSD_{0.05}$	-	-	-	1.61	-
Plant densities					
D1	64942	13.8	26.1	362.5	9.24
D2	63603	13.8	26.5	363.08	7.95
D3	62077	14.6	27.1	363.58	7.88
F-test	*	NS	NS	NS	**
$LSD_{0.05}$	2242.7	-	-	-	0.72
CV,%	4.2	3.2	5.8	3.6	8.3
Grand mean	63541	13.9	26.6	363.06	10.36

Note: Note: NK=no of Kernel, NKR=No of Kernel Rows, TGW= Thousand Grain Weight NT=No Tillage, CT=Conventional Tillage, D1=60×25cm, D2=70×25cm, D3=75×25cm

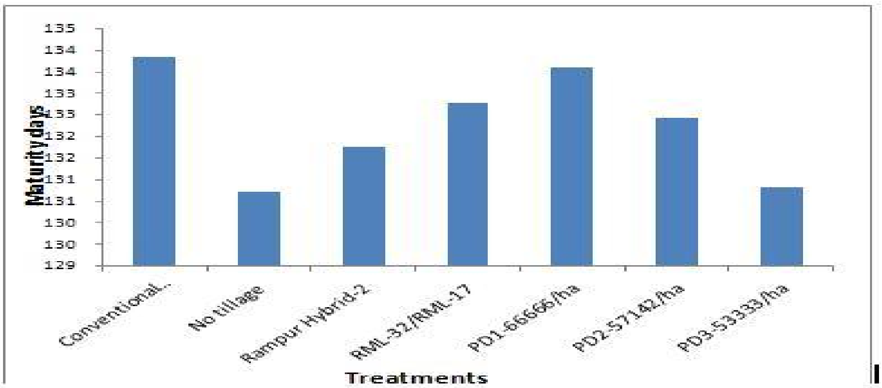

Fig 3. Physiological maturity of Rampur Hybrid-2 and RML-32/RML-17 under various tillage methods and planting geometries in Rampur, during spring, 2013

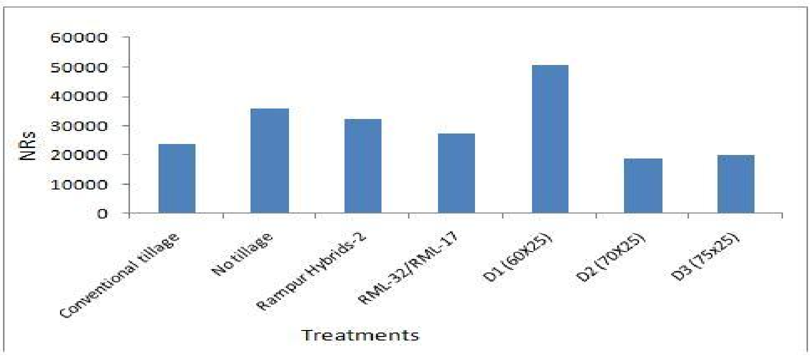

Fig 4. Net return (NRs/ha) as affected b various tillage methods, genotypes and plant densities, Rampur, 2014

Table 4. Summary of the economic analysis of various tillage methods, hybrids and plant densities, Rampur, 2014

Treatment	Gross return (NRs/ha)	Net return (NRs)	BC ratio
Tillage methods			
Conventional tillage	158199.98	23903.98	1.18
No tillage	136266.77	36270.77	1.36
Hybrids			
Rampur Hybrids-2	149598.64	32452.64	1.29
RML-32/RML-17	144868.12	27722.12	1.25
Plant densities			
D1 (60×25)	168178.22	51032.22	1.46
D2 (70×25)	136191.18	19045.18	1.16
D3 (75×25)	137330.74	20184.74	1.19

Table 5. Effect of tillage, hybrids and planting densities on the soil pH and organic matter content, Rampur, 2014

Treatment	Soil pH	Soil organic matter (%)
Tillage methods		
Conventional tillage	5.46	2.43
No tillage	5.55	2.60
F test	NS	*
$LSD_{0.05}$	0.58	0.03
Hybrids		
Rampur Hybrid-2	5.52	2.50
RML-32/RML-17	5.49	2.51
F test	NS	NS
$LSD_{0.05}$	-	-
Plant densities		
D1 (60×25)	5.46	2.46
D2 (70×25)	5.49	2.51
D3 (75×25)	5.55	2.52
F test	NS	NS
$LSD_{0.05}$	-	-
CV,%	1.5	3.7
Grand mean	**5.50**	2.49

REFERENCES

Abuzar, M.R., Sadozai, G. U, Baloch, M. S., Baloch, A. A., Shah, I. H. Javaid, T & Hussain, N. (2011). Effect of plant population on densities on yield of maize. *The Journal of Animal & Plant Sciences*, 21(4), 692-695.

Ali, R., Khalil, S. K., Raza, S. M. & Khan, H. (2003). Effect of herbicides and row spacing on maize. *Pak. J. Weed Sci. Res.* 9(3-4), 171-178.

Amanullah, R., Khattak, A, & Khalil, S. K. (2009). Plant Density and Nitrogen Effects on Maize Phenology and Grain Yield. *Journal of Plant Nutrition*, 32, 246–260.

Araus, L., Slafer, G.A, Royo, C. & Serret, M.D. (2008). Breeding for yield potential and stress adaptation in cereals. *Crit. Rev. Plant Sci*. 27, 377–412.

Bisht, A.S., Bhatnagar, A., Pal, M.S. & Singh, V. (2012). Growth Dynamics, Productivity and Economics of Quality Protein Maize (Zea mays L.) Under Varying Plant Density and Nutrient Management Practices. *Madras Agric. J.,* 99 (1-3), 73-76.

Board, J. E., Kamal, M., and Harville, B. G. (1992). Temporal importance of greater light interception to increased yield in narrow-row soybean. *Agronomy Journal*, 84, 575–579.

CTIC. (2015). Conservation Technology Information Centre. 3495 Kent Avenue, West Lafayette, Indiana : http://www.ctic.purdue.edu/

Gonzalo, M., Vyn, T.J., Hollan, J.B & McLntyre, L. M. (2006). Mapping density response in maize: A direct approach for testing genotype and treatment interactions. *Genetics*, 173, 331-348.

Hamid, A & Nasab, A. D. M. (2001). The effect of various plant densities and N levels on phenology of two medium maturity corn hybrids. *Iranian. J. Agri. Sci.* 32, 857–874.

Liu, W., Tollenaar, M. & Smith, G. (2004). Within row plant spacing variability does not affect corn yield. *Agron. J.* 96, 275-280.

Luque, S. F., Cirilo, A. G. & Otegui, M. E. (2006). Genetic gains in grain yield and related physiological attributes in Argentine maize hybrids. *Field Crop Res*. 95, 383-397.

Mashiqa, P., Lekgari, L. & Ngwako, S. (2011). Effect of plant density on yield and yield components of maize in Botswana. *World of Sciences Journal*. 1 (7), 173-179.

MOAD. (2014). Statistical information on Nepalese Agriculture 2012/2013. Agri-Business Promotion and Statistics Division. Ministry of Agriculture and Development. Singhadurbar, Kathmandu Nepal.

NDSU. (1999). Equity, Diversity and Global Outreach, North Dakota State University. 205 Old Main, (701) 231-7708.

Paudyal, K.R. & Ransom, J.K. (2001). Resources Use Efficiency and Effective Incentives to Nepalese Maize Farmers. Sustainable Maize Production Systems for Nepal. Proceedings of Maize Symposium. 3-4 December, 2001, Kathmandu, Nepal.

Sangakkara, U. R., Bandaranayake, P. S., Gajanayake, J. N. & Stamp, P. (2004). Plant populations and yield of rain-fed maize grown in wet and dry seasons of the tropics. *Maydica*, 49, 83-88.

Sangoi, L. & Salvador, RJ. (1997). Influence of plant height and leaf number on maize production at high plant densities. Univ. do Estado de Santa Catarina (UDESC), Caixa Postal 281, CEP 88520-000 Lages, SC. Bolsista.

Shahzad, I., Arif, M, Khan, A., Ali Khan, M., Shah, W., & Latif, A. (2015). Effect of Nitrogen Levels and Plant Population on Yield and Yield Components of Maize. *Advances in Crop Science and Technology*. 3, 170.

Sornpoon, W. & Jayasuriya, H.P.W. (2013). Effect of different tillage and residue management practices on growth and yield of corn cultivation in Thailand. *J. Agric Eng Int.,* 15 (3), 86-94.

Tollenaar, M., Dwer, L.M., & Steart, D.W. (2000a). Physiological parameters associated with differences in kernel set among maize hybrids. pp. 115-130. In: M.A. Westgate, K.J. Boote (Eds.), Physiology and modeling kernel set in maize. CSSA Spec. Publ. 51, CSSA/ASA/SSSA, Madison, WI.

Vega, C.R.C., Andrade, F.H, Sadras, V.O., Uhart, S.A. & Valentinuz, O. R. (2001). Seed number as a function of growth. A comparative study in soy-bean, sunflower, and maize. *Crop Sci.* 41, 748–754.

Wang, X., Baoyuan, Z. Xuefang, S. Yang, Y. Wei, M., & Ming, M.A. (2015). Soil Tillage Management Affects Maize Grain Yield by Regulating Spatial Distribution Coordination of Roots, Soil Moisture and Nitrogen Status. PLoS One, 10, 6.

Xue, J., Liang, Z.G.M., Lu, H. ,& Ren, J. (2002). Population physiological indices on density-tolerance of maize in different plant type. *Ying Yong Sheng Tai Xue Bao*, 13, 55-59.

Zhang, L., Vander Werf, W., Bastiaans, L., Zhang, S., Li, B., & Spiertz, J.H.J. (2008). Light interception and utilization in relay intercrops of wheat and cotton. *Field Crops Research*, 107 (1), 29–42.