International Journal of Global Science Research **ISSN: 2348-8344 (Online)**
Vol. 6, Issue. 1, April 2019, pp. 1023-1037 **DOI: 10.26540/ijgsr.v6.i1.2019.132**
***Available Online* at www.ijgsr.com**

Research Paper

Effect of different genotypes, tillage methods and plant populations on dry matter, grain yield, stover yield and harvest index of hybrid maize

Surya Bahadur Thapa[1]*, Pratikshya Shrestha[1], Shrawan Kumar Sah[1], Tika Bahadur Karki[1], Jiban Shrestha[2], Krishna Aryal[3] and Bishnu Prasad Kandel[4]

[1]Agriculture and Forestry University (AFU), Rampur, Chitwan, Nepal
[2]Nepal Agricultural Research Council, Agriculture Botany Division, Khumaltar, Lalitpur, Nepal
[3]Department of Soil Science, Post Graduate Program, Institute of Agriculture and Animal Science, Tribhuvan University, Kirtipur, Nepal
[4]Department of Plant Breeding, Post Graduate Program, Institute of Agriculture and Animal Science, Tribhuvan University, Kirtipur, Nepal
*Corresponding author E-mail: thapasurya172@gmail.com

Received: 20/03/2019
Revised: 20/04/2019
Accepted: 28/04/2019

Abstract: An experiment was conducted to assess the effect of genotypes, tillage methods and plant populations on dry matter, grain yield, stover yield and harvest index of hybrid maize at research field of National Maize Research Program (NMRP), Rampur, Chitwan, Nepal during winter season of 2015/16. The experiment was laid out in strip-split plot design that consisting of two hybrids as horizontal factor (Rampur hybrid 4 and Rampur hybrid 6), two tillage methods as vertical factors (zero and conventional tillage) and four plant populations (55,555, 69,444, 85,470 and 1,01,010 plants ha^{-1}) as sub-sub plot factors. Rampur hybrid 6 produced more dry matter as compared to Rampur hybrid 4 except early stage (30 DAS). Rampur hybrid 6 produced slightly higher grain yield (6.11 t ha^{-1}) than Rampur hybrid 4 (5.88 t ha^{-1}). Grain yield under zero tillage (6.25 t ha^{-1}) was similar to conventional tillage (5.74 t ha^{-1}). Significantly higher grain yield (6.54 t ha^{-1}) was obtained from the population of 85,470 plants ha^{-1} than 55,555 (5.31 t ha^{-1}) and 69,444 (5.92 t ha^{-1}) plants ha^{-1} but remained at par with 1,01,010 plants ha^{-1} (6.21 t ha^{-1}) which was similar to 69,444 plants ha^{-1} but significantly superior over 55,555 plants ha^{-1} Thus, it can be mentioned that both hybrid maize varieties

(Rampur hybrid 4 and Rampur hybrid 6) can be successfully grown under zero tillage system with optimum plant population of 85,470 plants ha^{-1} to achieve higher grain yield and net return during winter season at Rampur, Chitwan, Nepal. Stover yield was found to increase with the increase in plant population from 55,555 to 1,01,0101 plants ha^{-1}, more in zero tillage but not significantly influenced by Hybrid varieties.

Keywords: Hybrid maize, optimum plant population, zero tillage,

1 INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crops next to wheat and rice in the world. Moreover, it is one of the most versatile and emerging crops due to its wider adaptability and successful cultivation in diverse seasons and ecologies for various purposes (Riedelsheimer et al., 2012). It is called "Queen of cereals" as it is grown throughout the year due to its photo-thermo-insensitive character and the highest genetic yield potential among the cereals. It is the second most important cereal crop in terms of area, production and productivity after rice in Nepal (MOAD, 2015). It is cultivated in 0.92 million hectares (ha) of lands with the production and productivity of 2.28 million ton (t) and 2.46 t ha^{-1}, respectively (MOAD, 2015). Maize occupies 30.04% of total cultivated agricultural land and shares about 23.87% of the total cereal production of Nepal (MOAD, 2015). It is grown in an area of 9750 hectare (ha) with the production of 29250 metric ton (t) in Chitwan district and the yield is 3.0 t ha^{-1} (MOAD, 2015). It contributes 3.15% to national GDP and 9.5% to agricultural GDP (MOAD, 2015).The proportion of maize area consists of 70% in mid hills followed by 22% in terai and 8% in high hills (KC et al., 2015). In spite of suitable production environment and high yielding varieties of maize, the yield per hectare in Nepal (2.458 t ha^{-1}) is still very low as compared to USA, China and Brazil (10.73, 5.81 and 5.40 t ha^{-1}, respectively). Among different factors, hybrids, tillage and plant population can be considered as important factors which can contribute to improve grain yield of maize in our condition (Karki et al., 2015). Therefore, recently conservation tillage practices such as zero and minimum tillage are emphasized for soil water conservation, fuel energy saving and erosion control (Sharafi et al., 2009). Hence, zero and minimum tillage may be introduced to offset the production cost and other constraints associated with environment and socio-economic conditions (Jat et al., 2006).

There are a number of biotic and abiotic factors which affect maize yield considerably. However, it 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.

Moreover, Sharifi et al. (2009) also mentioned that maize hybrids differ in their response to plant density. Also, appropriate plant spacing gives the right

International Journal of Global Science Research
Vol. 6, Issue. 1, April 2019, pp. 1023-1037
***Available Online* at www.ijgsr.com**

ISSN: 2348-8344 (Online)
DOI: 10.26540/ijgsr.v6.i1.2019.132

plant density, which is the number of plants, allowed on a given unit of land for optimum yield (Obi, 1991). Thus, plant spacing is an important agronomic input parameter since it is believed to have effects on light interception during which photosynthesis takes place which is the energy manufacturing medium using green parts of the plant.

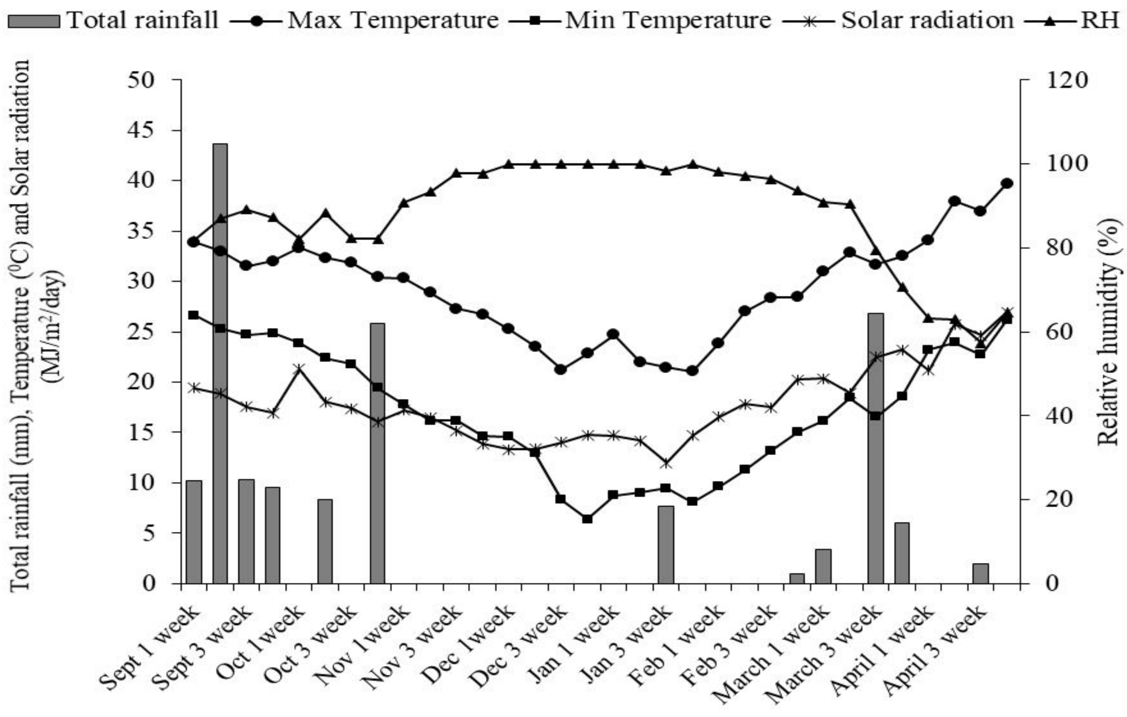
Many studies have been conducted with the aim of determining the optimum plant population for maize within and outside the country. Unfortunately, there is no single and robust recommendation, because the optimum plant density varies depending on environmental factors such as crop establishment methods i.e. tillage, soil fertility, moisture supply and genotype (Gonzalo et al., 2006). This research is conducted with the aim of finding the higher yield maize genotypes under optimum plant population and tillage method.

2. MATERIALS AND METHODS

2.1 Description of the experimental site

A field experiment was conducted during winter season (October, 2015 to March, 2016) at the research farm of National Maize Research Program (NMRP), Rampur, Chitwan, Nepal. The experimental site is 10 km far towards south–west direction from headquarter of Chitwan district, Bharatpur. It is located at 27^0 37' North latitude and 84^0 25' East longitude with an elevation of 256 meter above mean sea level. Weather condition during the course of experimentation

The annual precipitation of given area is about 1919.5 mm (NMRP, 2000). The average data at an interval of two weeks on different weather parameters i.e., maximum and minimum temperatures, total rainfall and relative humidity, recorded during the maize growing season at NMRP are presented in Figure 1.



International Journal of Global Science Research
Vol. 6, Issue. 1, April 2019, pp. 1023-1037
***Available Online* at www.ijgsr.com**

ISSN: 2348-8344 (Online)
DOI: 10.26540/ijgsr.v6.i1.2019.132

Figure 1. Weather condition during the course of experimentation at NMRP, Rampur, Chitwan, Nepal, 2015/16.

2.2 Experimental details

The experiment was laid out in strip-split plot design consisting of 16 treatments with three replications. Four different levels of planting geometry (60 cm×30 cm, 60 cm×24 cm, 60 cm×19.5 cm and 60 cm×16.5 cm representing 55,555, 69,444, 85,470 and 1,01,010 plants ha^{-1}, respectively), two hybrid varieties of maize (Rampur hybrid 4 and Rampur hybrid 6) and two tillage methods (conventional and zero tillage) were used as the treatments. The size of each plot was 6 m×3.6 m. The distance between the replication was 1 m and plots 50 cm.

2.2.2 Treatment details

Horizontal factor: Genotypes
(a) Rampur hybrid 4 (V1)
(b) Rampur hybrid 6 (V2)

Vertical factor: Tillage practices
(a) Zero tillage (ZT)
(b) Conventional tillage (CT)

Sub-sub plot factor: Plant population
(a) 55,555 plants ha^{-1} (60 cm×30 cm) (c) 85,470 plants ha^{-1} (60 cm×19.5 cm)
(b) 69,444 plants ha^{-1} (60 cm×24 cm) (d) 1,01,010 plants ha^{-1} (60 cm×16.5 cm)

2.3 Cultural practices

2.3.1 Field preparation

The experimental plots for conventional tillage were prepared by ploughing the plots 13 days prior to sowing seeds with tractor. For zero tillage, the field was sprayed with glyphosate 47/VL using recommended dose (5 mL per liter of water) to make field free from weeds. Manually, stubbles of previous crops and weeds were removed prior to sowing seeds. The layout of the field was done by making 48 plots ı Page 725 tapes, spades and white powder.

2.3.2 Seed rate and sowing

Bold and healthy seeds were selected for the experiment. Three seeds per hill were sown in all rows by Jap planter. Seeds were sown at a distance between 30 cm, 24 cm, 19.5 cm and 16.5 cm for respective treatment with row spacing of 60 cm. Seeds were sown on 3rd of October 2015. Gap filling/re-sowing was done 8 days after sowing to maintain optimum plant population. All intercultural practices (Thinning, irrigation, weeding, plant protection) were done as per National recommendation practices.

2.3.4 Data collection and analysis

All collected data were entered in Microsoft Excel 2016 and analyzed by Computer software like Statistical Package R, SPSS version 20.

3. RESULTS AND DISCUSSION

3.1 Dry matter production

The total dry matter accumulated in maize plants was not influenced significantly by hybrid varieties in almost all growth stages. However, it was significantly higher in Rampur hybrid 6 (1,748 kg ha^{-1}) as compared to Rampur hybrid 4 (1,578 kg ha^{-1}) at 45 DAS. Similarly, the value of total dry matter accumulated was non significantly higher in Rampur hybrid 4 (945 kg ha^{-1}) than Rampur hybrid 6 (827 kg ha^{-1}) only at

International Journal of Global Science Research **ISSN: 2348-8344 (Online)**
Vol. 6, Issue. 1, April 2019, pp. 1023-1037 **DOI: 10.26540/ijgsr.v6.i1.2019.132**
***Available Online* at** www.ijgsr.com

early growth stage (30 DAS) whereas after near to tasseling stage (60 DAS), the values of total dry matter accumulated was remarkably higher in Rampur hybrid 6 than Rampur hybrid 4 up to the physiological maturity stage.

Further, the values of leaf dry matter accumulation in both hybrids were not significantly different at all growth stages. However, it was non-significantly higher in Rampur hybrid 4 Page 726 kg ha^{-1}) than Rampur hybrid 6 (522 and 1,991 kg ha^{-1}) at 30 and 150 DAS, respectively

Similarly, the dry matter accumulated in stem of maize hybrids also did not differ significantly at most of the growth stages. However, it was significantly higher in Rampur hybrid 6 (849 kg ha^{-1}) than Rampur hybrid 4 (717 kg ha^{-1}) only at 45 DAS.

Finally, dry matter deposited in cobs also did not differ significantly due to change in hybrid varieties at all growth stages. It was non-significantly higher in Rampur hybrid 4 (2,521 kg ha^{-1}) as compared to Rampur hybrid 6 (2,396 kg ha^{-1}) at 90 DAS only. On the other hand, the dry matter deposited in cobs was non-significantly higher in Rampur hybrid 6 than Rampur hybrid 4 at the remaining growth stages.

Further, the total dry matter accumulated by hybrid maize plants was also not influenced significantly by the tillage methods at all the crop growth stages. However, the values of total dry matter accumulation recorded in zero tillage were remarkably higher than that of conventional tillage.

In case of leaf dry matter accumulation, it was significantly higher in zero tillage than conventional at 90, 120, 135 and 150 DAS. On the other hand, the values of leaf dry matter recorded in zero tillage were non significantly higher than in conventional tillage at 30, 45, 60, 75, 105 and 172 DAS, respectively.

Further, values of the stem dry matter recorded in zero tillage (8,678, 8,877 and 4,609 kg ha^{-1}) were also significantly higher in comparison to conventional tillage (5,951, 6,561 and 3,501 kg ha^{-1}) at 90, 105 and 172 DAS, respectively

Finally, the cob dry matter deposited in zero tillage (5,108 kg ha^{-1}) was significantly higher than that of conventional tillage (4,665 kg ha^{-1}) only at near milking stage (105 DAS) whereas at other stages it was similar but higher in zero than conventional tillage at 75, 90, 120, 135, 150 and 172 DAS, respectively.

Similarly, the tillage methods did not differ significantly in dry matter accumulation however the values were non-significantly higher in zero tillage as compared to conventional tillage at almost all the growth stages. Similar was the findings of Sharma, (2014) who reported non-significant difference in total dry matter accumulation of hybrid maize plants under zero and conventional tillage system during summer season of 2014 at Rampur, Chitwan. On the other hand, Chopra and Angiras (2007) mentioned that the value of dry matter accumulation recorded in conventional tillage (113.56 g m^{-2}) was significantly higher as compared to zero tillage (99.23 g m^{-2}) during kharif season in Himanchal

International Journal of Global Science Research **ISSN: 2348-8344 (Online)**
Vol. 6, Issue. 1, April 2019, pp. 1023-1037 **DOI: 10.26540/ijgsr.v6.i1.2019.132**
***Available Online* at www.ijgsr.com**

Pradesh. Thus, it is obvious that the significant differences between tillage methods in respect of dry matter accumulation in maize plants depends on its growing condition, season and region of cultivation.

Further, the total dry matter accumulated by hybrid maize plants was influenced significantly by the change in plant population.

Thus, from the beginning to the approach of silking stage (30-75 DAS) and from physiological maturity to harvest (150-172 DAS) stage, both Page 727 55 and 69 thousand plants ha^{-1} were at par but from seed formation stage (90 DAS) to the approach of dough stage (135 DAS), they differed significantly with respect to total dry matter accumulation in maize plants.

Moreover, the total dry matter accumulation in the plants increased significantly at almost all growth stages owing to increase in plant population from 69 to 85 thousand plants ha^{-1} and thereafter the increment in total dry matter was not significant. In spite of it, the values of total dry matter was increasing significantly with the increase in plant population from 55 to 85 and then remained at par with 101 thousand plants ha^{-1} from near milking (105 DAS) to the approach of dough stage (135 DAS).

Leaf , stem dry matter increased in increasing the plant population up to 85 thousand plants ha^{-1} which is significantly different then (55 and 69 thousand plants ha^{-1}) but statistically at par with 101 thousand plants per hectare in 30, 45, 60, 75, 90, 105, 120, 135, 150, 172 days respectively.

This indicates that an optimum plant population for maximum economic yield exist for all crop species and varies with cultivar and environment (Bruns and Abbas, 2005).

Table 2. Dry matter accumulation of maize hybrids as influenced by tillage methods and plant population during winter season at NMRP, Rampur, Chitwan, Nepal, 2015/16

Treatments	Dry matter accumulation (kg ha^{-1})					
	30 DAS			45 DAS		
Varieties	Leaf	Stem	Total	Leaf	Stem	Total
Rampur hybrid 4	607	338	945	861	717^{b}	1578^{b}
Rampur hybrid 6	522	304	827	898	849^{a}	1748^{a}
LSD (=0.05)	ns	ns	ns	ns	23.9	76.6
SEm (±)	25.6	19.6	43.5	14.9	3.9	12.6
Tillage methods						
ZT	600	333	933	889	856	1745
CT	530	309	839.	870	710	1580
LSD (=0.05)	ns	ns	ns	ns	ns	Ns
SEm (±)	55.1	30.0	84.7	26.4	82.5	104.7
Plant population (ha^{-1})						
55,555	396^{b}	232^{b}	628^{b}	751^{b}	666^{c}	1417^{b}
69,444	527^{b}	280^{b}	807^{b}	788^{b}	760^{b}	1548^{b}
85,470	524^{b}	302^{b}	826^{b}	942^{a}	836^{a}	1778^{a}
1,01,010	812^{a}	470^{a}	1282^{a}	1036^{a}	871^{a}	1907^{a}
LSD (=0.05)	175.2	105.1	275.5	104.2	70.3	147.9

International Journal of Global Science Research **ISSN: 2348-8344 (Online)**
Vol. 6, Issue. 1, April 2019, pp. 1023-1037 **DOI: 10.26540/ijgsr.v6.i1.2019.132**
***Available Online* at www.ijgsr.com**

SEm (±)	60.0	36.0	94.4	35.7	24.1	50.7
CV %	36.8	38.9	36.9	14.1	10.7	10.6
Grand mean	565	321	886	879	783	1663

Means followed by the common letter(s) within each column are not significantly different at 5% level of significance by DMRT; ns= non-significant; DAS= days after sowing

Table 3. Dry matter accumulation of maize hybrids as influenced by tillage methods and plant population during winter season at NMRP, Rampur, Chitwan, Nepal, 2015/16

Page 728

Treatments	Dry matter accumulation (kg ha^{-1})						
	60 DAS			75 DAS			
	Leaf	Stem	Total	Leaf	Stem	Cob	Total
Varieties							
Rampur hybrid 4	2429	2841	5270	2838	4761	1075	8674
Rampur hybrid 6	2522	2993	5515	2988	5176	1159	9322
LSD (=0.05)	ns	ns	ns	ns	ns	ns	Ns
SEm (±)	178.4	310.9	487.5	206.5	759.0	150.1	821.5
Tillage methods							
ZT	2501	2743	5244	3104	5370	1140	9614
CT	2451	3091	5542	2722	4567	1094	8382
LSD (=0.05)	ns	ns	ns	ns	ns	ns	Ns
SEm (±)	99.8	252.9	351.1	192.8	182.0	161.4	514.3
Plant population (ha^{-1})							
55,555	1867^{b}	2203^{b}	4071^{b}	2420	3997^{b}	975^{c}	7393^{b}
69,444	2110^{b}	2449^{b}	4559^{b}	2709	3490^{b}	1055^{bc}	7253^{b}
85,470	2842^{a}	3439^{a}	6281^{a}	2908	5852^{a}	1174^{ab}	9934^{a}
1,01,010	3085^{a}	3577^{a}	6661^{a}	3615	6535^{a}	1263^{a}	11413^{a}
LSD (=0.05)	470.6	767.6	1213.7	ns	1442.0	128.8	2279.1
SEm (±)	161.2	263.0	415.8	342.6	494.1	44.1	780.8
CV %	22.6	31.2	26.7	40.7	34.4	13.7	30.1
Grand mean	2476	2917	5393	2913	4968	1117	8998

Means followed by the common letter(s) within each column are not significantly different at 5% level of significance by DMRT; ns = non-significant; DAS Days after sowing

Table 4. Dry matter accumulation of maize hybrids as influenced by tillage methods and plant population during winter season at NMRP, Rampur, Chitwan, Nepal, 2015/16

Treatments	Dry matter accumulation (kg ha^{-1})							
	90 DAS				105 DAS			
	Leaf	Stem	Cob	Total	Leaf	Stem	Cob	Total
Varieties								
Rampur hybrid 4	3185	6799	2521	12504	2868	7153	4883	14904
Rampur hybrid 6	3243	7829	2396	13468	3048	8285	4891	16224
LSD (=0.05)	ns	ns	ns	ns	ns	ns	ns	ns
SEm (±)	91.5	558.8	163.0	754.3	217.8	275.3	221.0	691.7
Tillage methods								
ZT	3539^{a}	8678^{a}	2853	15070^{a}	3306	8877^{a}	5108^{a}	17291
CT	2889^{b}	5951^{b}	2064	10903^{b}	2611	6561^{b}	4665^{b}	13837
LSD (=0.05)	596.9	1242.2	ns	1417.5	ns	2271.8	422.1	ns
SEm (±)	98.1	20.4	164.6	232.9	225.0	373.3	69.4	623.6
Plant population (ha^{-1})								

International Journal of Global Science Research **ISSN: 2348-8344 (Online)**
Vol. 6, Issue. 1, April 2019, pp. 1023-1037 **DOI: 10.26540/ijgsr.v6.i1.2019.132**
***Available Online* at** www.ijgsr.com

55,555	2731^{c}	4925^{c}	1559^{c}	9214^{c}	2405^{c}	5274^{c}	3643b	11322c
69,444	2913^{bc}	6914^{b}	2306^{b}	12133^{b}	2686^{bc}	7295^{b}	4448b	14428b
85,470	3261^{b}	8308^{ab}	2866^{ab}	14435^{ab}	3058^{b}	8788^{a}	5689a	17535a
1,01,010	3952^{a}	9110^{a}	3102^{a}	16163^{a}	3684^{a}	9519^{a}	5767a	18970a
LSD (=0.05)	446.6	1974.6	680.8	2546.8	410.9	1011.2	1165.4	1874.0
SEm (±)	153.0	676.5	233.2	872.6	140.8	346.4	399.3	642.0
CV %	16.5	32.0	32.9	23.3	16.5	15.5	28.3	14.3
Grand mean	3214	7314	2458	12986	2958	7719	4887	15564

Means followed by the common letter(s) within each column are not significantly different at 5% level of significance by DMRT; ns = non-significant; DAS Days after sowing

Table 5. Dry matter accumulation of maize hybrids as influenced by tillage methods and plant population during winter season at NMRP, Rampur, Chitwan, Nepal, 2015/16

Treatments	Dry matter accumulation (kg ha^{-1})							
	120 DAS				135 DAS			Page 729
	Leaf	Stem	Cob	Total	Leaf	Stem	Cob	Total
Varieties								
Rampur hybrid 4	2464	6620	6260	15343	2226	5757	8114	16097
Rampur hybrid 6	2741	7724	6697	17162	2446	6889	8507	17842
LSD (=0.05)	ns	ns	ns	ns	ns	ns	ns	ns
SEm (±)	301.1	725.9	739.5	1721.3	172.7	478.0	421.5	1041.7
Tillage methods								
ZT	2938^{a}	8219	6721	17879	2625^{a}	7191	8404	18220
CT	2267^{b}	6125	6236	14627	2048^{b}	5454	8217	15719
LSD (=0.05)	290.3	ns	ns	ns	294.2	ns	ns	ns
SEm (±)	47.7	392.9	238.2	604.3	48.4	541.4	650.5	1181.3
Plant population (ha^{-1})								
55,555	1910^{c}	4974^{c}	4898^{b}	11682^{c}	1623^{c}	4121^{c}	6226^{b}	11970^{c}
69,444	2299^{c}	6907^{b}	5573^{b}	14780^{b}	2038^{bc}	5888^{b}	7492^{b}	15418^{b}
85,470	2759^{b}	8089^{a}	7575^{a}	18422^{a}	2563^{b}	7381^{a}	9569^{a}	19513^{a}
1,01,010	3443^{a}	8817^{a}	7867^{a}	20128^{a}	3121^{a}	7902^{a}	9954^{a}	20977^{a}
LSD (=0.05)	454.9	1080.2	1469.8	2614.3	549.2	950.6	1458.6	2384.0
SEm (±)	155.9	370.1	503.6	895.7	188.1	325.7	499.7	816.8
CV %	20.7	17.9	26.9	19.1	27.9	17.8	20.8	16.7
Grand mean	2602	7172	6478	16253	2336	6323	8310	16969

Means followed by the common letter(s) within each column are not significantly different at 5% level of significance by DMRT; ns = non-significant; DAS Days after sowing

Table 6. Dry matter accumulation of maize hybrids as influenced by tillage methods and plant population during winter season at NMRP, Rampur, Chitwan, Nepal, 2015/16

Treatments	Dry matter accumulation (kg ha^{-1})							
	150 DAS				At harvest (172 DAS)			
	Leaf	Stem	Cob	Total	Leaf	Stem	Cob	Total
Varieties								
Rampur hybrid 4	2023	4903	8706	15632	1159	3873	7477	12509
Rampur hybrid 6	1991	5286	8905	16182	1255	4237	8368	13861
LSD (=0.05)	ns	ns	ns	ns	ns	ns	ns	ns
SEm (±)	186.9	277.3	237.9	537.0	124.3	239.8	221.0	456.2
Tillage methods								
ZT	2410^{a}	5600	8969	16979	1363	4609^{a}	8050	14022
CT	1604^{b}	4589	8642	14835	1051	3501^{b}	7795	12348
LSD (=0.05)	220.4	ns	ns	ns	ns	599.8	ns	ns
SEm (±)	36.2	328.3	379.0	584.6	233.7	98.6	209.3	495.3
Plant population (ha^{-1})								

55,555	1521[c]	3598[c]	6673[b]	11793[b]	966[b]	3029[b]	5841[b]	9836[b]
69,444	1819[bc]	4540[bc]	7868[b]	14227[b]	1051[b]	3330[b]	7040[b]	11422[b]
85,470	2245[ab]	5984[ab]	10005[a]	18233[a]	1205[b]	4754[a]	9111[a]	15071[a]
1,01,010	2442[a]	6255[a]	10677[a]	19374[a]	1605[a]	5109[a]	9698[a]	16411[a]
LSD (=0.05)	543.4	1447.2	1342.5	2747.7	264.3	859.6	1237.7	1732.0
SEm (±)	186.2	495.8	459.9	941.4	90.5	294.5	424.1	593.4
CV %	32.1	33.7	18.1	20.5	26.0	25.2	18.5	15.6
Grand mean	2007	5094	8806	15907	1207	4055	7923	13185

Means followed by the common letter(s) within each column are not significantly different at 5% level of significance by DMRT; ns = non-significant; DAS Days after sowing

Finally, non-significant differences between higher plant populations with respect to grain yield of hybrid maize was also observed by Sarwar et al. (2016) in Bangladesh, Bisht et al. (2012) in India Malaviarachchi et al. (2007 and Adeniyan (2014) in Nigeria.

Page 730

3.2 Grain yield

Crop yield is the economic part of plant used for human or animal consumption and measured as grains or dry matter quantity per unit land area (Fageria, 2013). Further, the grain yield is a product of a number of sub fractions called yield associated traits and sub fractions are the number of reproductive plants per unit area, maturity of plants, the number of grains per reproductive unit and average weight per unit (Wajid et al., 2007).

Basically it is determined by the action of numerous genes, many of which affect vital processes within a plant, such as nutrition, photosynthesis, transpiration and storage of food materials (Saleem, et al., 2004). Moreover, grain yield is the function of genotypes × environment interaction (Annicchiarico, 2002).

Thus, the average grain yield of hybrid maize recorded in the experiment was 6.0 t ha^{-1} and ranged from 3.19 to 7.76 t ha^{-1} depending upon the varieties, tillage practices and plant densities.

In this experiment, the Rampur hybrid 6 produced higher grain yield (6.11 t ha^{-1}) as compared to Rampur hybrid 4 (5.88 t ha^{-1}) but the differences was not significant.

The results of this experiment showed that the tillage methods did not affect significantly on grain yields of hybrid maize. However, zero tillage gave higher grain yield (6.25 t ha^{-1}) in comparison to conventional tillage (5.74 t ha^{-1}). Pandey and Chaudhary (2014) reported that grain yields were not affected significantly by tillage methods (7.53 and 7.37 ton ha^{-1} in conventional and zero tillage, respectively) in Chitwan, Nepal. Similar results were obtained by Srivastav (2013) in Chitwan, Nepal.in Contrast to our findings Iqbal et al. (2013) observed that the grain yield obtained from conventional tillage (7.3 t ha^{-1}) was significantly greater than minimum tillage (6.3 t ha^{-1}) and no tillage (5.7 t ha^{-1}) which were also significantly different from each other in the condition of Faisalabad, Pakistan. Thus, it is obvious that the significant differences between tillage methods in respect of dry matter

International Journal of Global Science Research **ISSN: 2348-8344 (Online)**
Vol. 6, Issue. 1, April 2019, pp. 1023-1037 **DOI: 10.26540/ijgsr.v6.i1.2019.132**
***Available Online* at** www.ijgsr.com

accumulation in maize plants depends on its growing condition, season and region of cultivation

Besides this, the plant density showed significant effect on grain yield formation of maize hybrids. Hence, significantly higher grain yield (6.54 t ha^{-1}) was obtained from the population of 85,470 plants ha^{-1} than 55,555 (5.31 t ha^{-1}) and 69,444 (5.92 t ha^{-1}), but remained at par with 1,01,010 plants ha^{-1} (6.21 t ha^{-1}) which was similar to 69,444 plants ha^{-1} but significantly superior over 55,555 plants ha^{-1} in respect of grain yield production. Finally, the difference in grain yields obtained from 55 and 69 thousand plants ha^{-1} was also significant.

Ragheb and Rassy (1989) reported that hybrids generally differ from each other in grain yield due to genetic factors and the different physiological performance. The physiological factors include extended root sys Page 731 root hairs to absorb more nutrients and the canopy architecture to intercept more photosynthetic light.

Moreover, the superiority of one variety over other with respect to yield component and yield might be related to its genetic potentiality to utilize and translocate photosynthates from source to sink and better adaptability to this agro-climatic conditions (Sampath et al., 2014). Thus, in this experiment hybrid varieties grown in winter season were similar to each other in respect of grain yield formation which means that they did not differ significantly in their genetic makeup or potential (Wajid et al., 2007; Mukhtar et al., 2011; Muhammad, Bakht et al., 2002) and capacity to transport photosynthates from source to sink.

3.3 Stover yield

The average stover yield of winter maize obtained in the experiment was 10.25 t ha^{-1} and ranged from 4.99 t ha^{-1} to 19.11 t ha^{-1} depending upon the treatments.

The stover yield was not significantly influenced by hybrids, however, it was remarkably higher in Rampur hybrid 6 (11.16 t ha^{-1}) as compared to Rampur hybrid 4 (9.33 t ha^{-1}). Banerjee et al. (2014) also observed non-significant effect between two hybrids i.e. Sona (6.24 t ha^{-1}) and Rajkumar (6.38 t ha^{-1}) in respect of stover yield in India, which is accordance to our findings. However, Dawadi and Sah (2012) reported that the stover yield was significantly higher in Gaurav (13.88 Page 731 Rajkumar (12.36 t ha^{-1}) maize hybrids grown during winter season in Rampur, Chitwan.

Stover yield was significantly influenced by the tillage methods. The stover yield produced by zero tillage (11.76 t ha^{-1}) was significantly higher than that of conventional tillage (8.73 t ha^{-1}). Similar result was obtained by Pandey and Chaudhary (2014) reported that slightly higher stover yield was obtained in conventional tillage (11.63 t ha^{-1}) in comparison to zero tillage (11.29 t ha^{-1}) in spring planted maize in Rampur, Chitwan.

Stover yield was found to increase with the increase in plant population from 55,555 to 1,01,0101 plants ha^{-1}. However, significantly higher stover yield was obtained with 1,01,010 (11.93 t ha^{-1}) plants

International Journal of Global Science Research **ISSN: 2348-8344 (Online)**
Vol. 6, Issue. 1, April 2019, pp. 1023-1037 **DOI: 10.26540/ijgsr.v6.i1.2019.132**
***Available Online* at www.ijgsr.com**

per hectare in comparison to 55,555 (8.48 t ha^{-1}) and 69,444 (9.56 t ha^{-1}) plants ha^{-1} but remained at par with 85,470 (11.02 t ha^{-1}) which was similar to 69,444 (9.56 t ha^{-1}) but significantly superior over 55,555 plants ha^{-1} (8.48 t ha^{-1}). The difference between lower plant populations i.e. 55 and 69 thousand plants ha^{-1} with respect to straw yield was not significant. Karki et al. (2015) reported that significantly higher stover yield (8.12 t ha^{-1}) was obtained with 66 thousand plants ha^{-1} in comparison to 53 (7.10 t ha^{-1}) and 57 (6.88 t ha^{-1}) thousand plants ha^{-1}. Dawadi and Sah (2012) reported that the stover yield was found to be significantly higher in 83,333 plants ha^{-1} (13.91 t ha^{-1}) as compared to 66,666 (13.17 t ha^{-1}) and 55,555 (12.29 t ha^{-1}) plants ha^{-1} in hybrid maize grown in winter season in Rampur, Chitwan. The variability in straw yield per hectare is the result of variation in the crop stand per unit area. These results are in line with the findings of Knapp and Reid (1981), Anjum (1987) and Tetio-Kagho and Gardner (1988).

3.4 Harvest index (HI)

Harvest index (HI) is a useful parameter to assess the translocation efficiency. Further, it was also reported that the yielding potential of a cultivar is usually associated with increased grain to straw ratio (Hirpadibaba et al., 2013). Harvest index is the ratio of grain yield and total upper ground biomass which indicates the efficiency of plant to assimilate partition to the parts of economic yield (i.e. maize grain). Higher harvest index means plant capacious to deposit assimilates having economic importance specially grain in case of cereals. The average harvest index of winter maize obtained in the experiment was 0.34 and ranged from 0.23 to 0.50 depending upon treatments.

Table 7. Grain yield (t ha^{-1}), stover yield (t ha^{-1}) and harvest index of maize hybrids as influenced by tillage methods and plant population during winter season at NMRP, Rampur, Chitwan, Nepal, 2015/16

Treatments	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Harvest index, HI
Varieties			
Rampur hybrid 4	5.88	9.33	0.35
Rampur hybrid 6	6.11	11.16	0.33
LSD (=0.05)	ns	ns	Ns
SEm (±)	0.19	0.97	0.02
Tillage methods			
ZT	6.25	11.76^{a}	0.32
CT	5.74	8.73^{b}	0.36
LSD (=0.05)	ns	2.17	Ns
SEm (±)	0.33	0.35	0.01
Plant population (ha^{-1})			
55,555	5.31^{c}	8.48^{c}	0.35
69,444	5.92^{b}	9.56^{bc}	0.36
85,470	6.54^{a}	11.02^{ab}	0.34
1,01,010	6.21^{ab}	11.93^{a}	0.31

LSD (=0.05)	0.58	2.08	Ns
SEm (±)	0.20	0.71	0.01
CV, %	11.6	24.2	15.8
Grand mean	6.0	10.25	0.34

Means followed by the common letter(s) within each column are not significantly different at 5% level of significance by DMRT; ns = non-significant

The maize hybrids did not significantly influence on harvest index. It was slightly higher in Rampur hybrid 4 (0.35) as compared to Rampur hybrid 6 (0.33). Singh et al. (2013) also observed non-significant effect between hybrids Dekalb DKC 7074 (43.3%), Dekalb Hishell (43 %), Dekalb Double (41.8 %), Dekalb 900 M (42.9 %) and Mahyco 3838 (41.5 %) in respect of harvest index. However, Dawadi and Sah (2012) observed significant difference in harvest index with hybrids. Significantly higher harvest index (0.46) was recorded with hybrid Rajkumar as compared to Gaurav (0.42) during winter season in Chitwan.

Further, the harvest index was not significantly affected by tillage methods, however, it was a little lower in zero tillage (0.32) as compared to conventional tillage (0.36). Pandey and Chaudhary (2014) recorded the same values of harvest index in conventional (0.39) and zero (0.39) tillage methods which is accordance to our findings.

Page 733

4. CONCLUSION

Both hybrid maize varieties (Rampur hybrid 4 and Rampur hybrid 6) can be successfully grown under zero tillage system with optimum plant population of 85,470 plants ha^{-1} to achieve higher grain yield and net return during winter season at Rampur, Chitwan, Nepal.

ACKNOWLEDGEMENT:

The authors are grateful to National Maize research Program (NMRP) Rampur, Chitwan, Nepal for providing the maize hybrid for research materials.

REFERENCES:

Riedelsheimer C., Czedik-Eysenberg A., Grieder C., Lisec J., Technow F., Sulpice R., and Melchinger A. E. (2012) Genomic and metabolic prediction of complex heterotic traits in hybrid maize. Nature genetics. *44*(2): 217-220.

MOAD. (2015) Statistical information on Nepalese agriculture 2014/15 (2071/072). Government of Nepal, Ministry of Agricultural Development, agribusiness promotion and Statistics Division, singhadurbar, Kathmandu, Nepal.

KC G., Karki T. B., Shrestha J., and Achhami B. B. (2015) Journal of Maize Research and Development (2015) 1 (1): 1-9. Journal of Maize Research and Development, *1*(1), 1-9.

Karki T. B., Govind K. C., Shrestha J., and Yadav J. P. (2015) Tillage and planting density affect the performance of maize hybrids in Chitwan, Neal. Journal of Maize Research and Development, *1*(1), 10-20.

Sharifi R. S., Sedghi M., and Gholipouri, A. (2009) Effect of population density on yield and yield attributes of maize hybrids. Research Journal of Biological Sciences, 4(4), 375-379.

Jat M. L., Sharma, S. K. Rai H. K., Srivastava A., and Gupta R. K. (2006) Effect of tillage on performance of winter maize in northern India. In Proceedings of the Maize Association of Australia, 6th Triennial Conference (pp. 293-299).

Vega C. R. C., Andrade F. H., and Sadras, V. O. (2001) Reproductive partitioning and seed set efficiency in soybean, sunflower and maize. Field Crops Research, *72*(3), 163-175.

Luque S. F., Cirilo A. G., and Otegui, M. E. (2006) Genetic gains in grain yield and related physiological attributes in Argentine maize hybrids. Field Crops Research, *95*(2), 383-397.

Liu W., Tollenaar M., Stewart G., and Deen, W. (2004) Within-row plant spacing variability does not affect corn yield. Agronomy Journal, 96(1), 275-280

Obi I. U. (1991) Maize*:* Its Agronomy, Diseases, Pests, and Food Values Optimal Computer Solutions Ltd. Enugu, Publishers. Agbani Road Enugu, Nigeria, XXVIII +, pp: 206.

Gonzalo M., Vyn T. J., Holland, J. B., and McIntyre, L. M. (2006) Mapping density response in maize: a direct approach for testing genotype and treatment interactions. Genetics, 173(1), 331-348.

NMRP Annual Report. (2000) Nepal Agriculture Research Council, Rampur, Chitwan, Nepal.

Chopra P., and Angiras N. N. (2007) Influence of tillage and weed control methods on growth, productivity and quality of maize (*Zea mays* L.). Journal of Crop and Weed, 3(2), 10-14.

Bruns H. A., and Abbas H. K. (2005) Ultra-high plant populations and nitrogen fertility effects on corn in the Mississippi valley. Agronomy Journal, 97(4), 1136-1140.

Bisht A. S., Bhatnagar A., Pal M. S., and 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.

Malaviarachchi M. A. P. W. K., Karunarathne K. M., and Jayawardane S. N. (2007) Influence of plant density on yield of hybrid maize (*Zea mays* L.) under supplementary irrigation. Journal of Agricultural Sciences, *3*(2).1-7.

Adeniyan O. N. (2014) Effect of different population densities and fertilizer rates on the performance of different maize varieties in two rain forest agro ecosystems of South West

ISSN: 2348-8344 (Online)
DOI: 10.26540/ijgsr.v6.i1.2019.132

Nigeria. African Journal of Plant Science, 8(8), 410-415.

Fageria, N.K. (2013) Maximizing crop yields, 1st ed.Vol 23. Pp 274.

Wajid A., Ghaffar A., Maqsood M., Hussain K., and Nasim W. (2007) Yield response of maize hybrids to varying nitrogen rates. Pak. J. Agri. Sci, 44(2): 217-220.

Pandey B., and Chaudhary N. K. (2014) Response of Tillage System, Nitrogen Level and Split Application of Nitrogen on Spring Maize in Chitwan, Nepal. International Journal of Applied Sciences and Biotechnology, *2*(3), 298-301.

Srivastav N. (2013) Weed dynamics and productivity of spring maize under different tillage and weed management methods, M.S. thesis (unpublished), Institute of Agriculture and Animal Science, Rampur, Nepal.

Iqbal M., Khan A. G., Hassan A., and Islam, K. R. (2013) Tillage and nitrogen fertilization impact on irrigated corn yields, and soil chemica Page 735 properties under semiarid climate. Journal of Sustainable Watershed Science and Management, *1*(3), 90-98.

Ragheb M.M., and H.N. Rassy. (1989) Response of some maize varieties to nitrogen fertilization. I. Vegetative growth and dry matter accumulation. Egypt. J. Agron. 12(1-2): 111-122.

Sampath O., Madhavi M., and Rao P. C. (2014) Evaluation of Genotypes and Nitrogen Levels for Yield Maximization in Rabi Maize (*Zea mays* L.). International Journal of Innovative Research and Development. 2(9).314-318.

Mukhtar T., Arif M., Hussain S., Tariq M., and Mehmood K. (2011) Effect of different rates of nitrogen and phosphorus fertilizers on growth and yield of maize. J. Agric. Res.*49* (3): 333-338.

Muhammad S., Bakht J., Jan M. T., Shah, W. A., and Khan N. P. (2002) NP levels effect on yield and yield components of maize varieties. Sarhad Journal of Agric 18, 17-25.

Dawadi D. R., and Sah S. K. (2012) Growth and yield of hybrid maize (*Zea mays* L.) in relation to planting density and nitrogen levels during winter season in Nepal. Tropical Agricultural Research, *23*(3), 218-227.

Knapp W. R., and Reid W. S. (1981) Interactions of hybrid maturity class, planting date, plant population, and nitrogen fertilization on corn performance in New York. Search agriculture-New York State Agricultural Experiment Station, Ithaca (USA).

Anjum J.I. (1987) Studies on the effect of plant population and fertilizer application on the growth and grain yield of summer maize. M.Sc. (Hons.) Agri. Thesis, Deptt. Agron. Univ. Agri., Faisalabad, Pakistan.

Tetio-Kagho F., and Gardner F. P. (1988) Responses of maize to plant population density. II. Reproductive development, yield, and yield adjustments. Agronomy Journal, *80*(6), 935-940.

Hirpadibaba D., Hunshal C. S., Hiremath, S. M., Awaknavar J. S., Wali M. C., Nadagouda, B. T., and Chandrashekar C. P. (2013) Performance of maize (*Zea mays* L.) hybrids as influenced by different levels of nitrogen, phosphorus, potassium and sulphur application. Karnataka Journal of Agricultural Sciences: *26*(2).194-199.
.

Page 736