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Effect of Conservation Agriculture on Growth and Productivity of Maize (*Zea mays* L.) in Terai Region of Nepal

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Abstract In order to evaluate the performance of hybrid and open pollinated varieties of maize under various conservation agriculture based practices in terai, region of Nepal, a field experiment was conducted at the research farm of National Maize Research Program (NMRP), Rampur, Chitwan, Nepal from February, 2012 to June, 2012. Altogether 16 treatments consisting of four maize varieties namely; DMH-849, Rajkumar, Manakamana-3 and Rampur Composite, and two levels of tillage, (i.e., conventional and no tillage) and two levels of residues management (i.e. with or without residue) were tested in 3 replication under split-split plot design. The data was analyzed using MSTATC statistical package. The results revealed that higher number of ears/ha was found in Manakamana-3 (54013) followed by Rajkumar hybrid (53550). The number of grains per ear was higher for residue left plot (406.04). Rajkumar hybrid produced the highest grain and stover yields of 7182 and 9996 kg/ha followed by 6295.0 and 9825.62 kg/ha in Manakamana-3. Variation on leaf area index (LAI) was due to no tillage was found significant in 45 DAS. Where as, the effect of residues on LAI was found significant at 30, 45, 60 and 75 DAS. Genotypic effect on LAI was found significant only at 30 DAS, where Manakamana-3 had the highest LAI (0.066) followed by DMH849 (0.056) and Rampur Composite (0.055). The variation due to tillage, residue and variety was evident for plant height in all the time series. The effect of residue on dry matter at 45 DAS was highly significant, where higher amount of dry matter was recorded in residue removed plots than the residue left plots. However, the hybrids DMH-849 had more grain to stover ratio (0.75) followed by Rajkumar (0.74) as compare to Rampur Composite (0.69). The plot having residues took longer duration for silking compared to the plot having no residue. Among the genotypes, DMH-849 showed earlier in tasseling (76 days) and maturity (118 days) followed by Rampur Composite. Economic analysis depicted the highest net return in Rajkumar hybrid (Rs. 105617/ha) under no tilled with residue used condition followed by without residue condition (Rs. 92267/ha). Manakamana-3 produced the higher net return (Rs. 85349/ha) under no tillage with no residue used condition followed by conventional tillage with no residue (Rs.70766/ha). The high benefit cost ratio was found of 2.432 in plots having no tillage with residue followed by no tilled with no residue 2.382. Manakamana-3 had the highest benefit cost ratio of 2.351 in no residue plots followed by no tilled with no residue plots (2.072). Significant reduction of production cost due to conservation agriculture (CA) based practices over conventional agriculture was recorded. Therefore, the CA based crop management practices need to be further promoted in wider areas.

Keywords: *maize hybrids, open pollinated varieties, conservation agriculture*

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1. Introduction

Maize (*Zea mays* L.) is the second most important staple food crop both in terms of area and production after rice in Nepal. It is grown in 9, 06,253 hectare of land with an average yield of 2280 kg/ha (ABPSD 2010/11). It occupies about 28.15% of the total cultivated agricultural land and shares about 23.28 % of the total cereal production in Nepal. It shares about 9.5 % to Agricultural Gross Domestic Product (ABPSD, 2009/2010). Maize is growing three distinct agro-climatic zones within Nepal, the terai and inner terai, the mid and the high-hills. In Nepal, it is the traditional crop cultivated as food, feed and fodder on slopping *Bari* land (rainfed upland) in the hills. In the terai, valleys and low-lying river basin areas (both *Bari* and *Khet* lands), maize is grown in the winter and spring seasons with partial irrigation (Poudyal *et al.*, 2001). Overall, 99.44% maize area is covered by improved open pollinated varieties (OPVs) including hybrids and only 0.56% local maize in terai (MoAC, 2009).There is rapid increase in maize demand primarily to meet the increased demand for human consumption in the hills as a staple food

and for livestock feeds in terai and inner terai areas. To meet the increased demand of poultry feed and year round consumption of the green maize in the cities the cultivation of maize is tremendously increasing day by day. Chitwan district itself is emerging as an industrial district especially for poultry industry. Out of 1,47,500 metric tons annual consumption of maize for poultry feed in Chitwan, only 41,796 metric tons produced in Chitwan and other are imported, mainly from India. Though there is a great potentiality of hybrid maize production especially in terai, valleys, and low river basin areas in different parts of Nepal. Some efforts have been made to develop and promote hybrid maize varieties in Nepal. Nevertheless, farmers from border areas of terai are introducing hybrid from abroad since long through Agro-vets and seed traders. The use of OPVs alone is not sufficient to fulfilling the food and feed demands because of its low productivity as compared to hybrids. Hybrid maize has great prospect to increase maize productivity in terai and mid hills under high input condition (Baniya *et al.*, 2004). Koirala *et al.* (2002) suggested that there is urgent need to promote the most promising hybrid maize for commercial cultivation. In recent years, the hybrid maize has been scaled up in the valleys and low hills of different parts of the country.Commercialization of hybrid maize production in the high input supply areas is strongly demanded and that would provide greater contribution to national economic growth (Pathik, 2002).

Therefore, to cope the demand for feeds by various feed industries located in terai and inner terai and to insure the food security in the hills of Nepal, increased in maize production per unit area through the adoption of hybrid cultivars is only the viable option. And economic cultivation is another option due high labor and input cost. So it is necessary to access the performance of hybrid varieties in this climatic scenario with different conservation agriculture based technologies for higher yields. Farmers are using their own technology based on either from recommendation of agro-vet or from Seed Company. The yield level in the terai as well as mid hills can be pushed up through the intervention in the prevailing practice with some promising technologies.

Tillage practices contribute greatly to the labor cost in any crop production system resulting to lower economic returns (Labios *et al.*, 1997).The minimum tillage could be a financially attractive technology for maize cultivation in rain fed lands of the mid hill and terai region. Since, minimum tillage is able to conserve a substantial amount of soil and nutrients; it has a long-term positive impact on the crop yield in comparison to the conventional tillage system. Therefore, the present study attempts to perform economic analysis of minimum tillage as a feasible resource conservation technology and implication for sustainable and resource-efficient agricultural production system in Nepal.

2. Materials and Method

A field experiment was conducted at National Maize Research Program (NMRP), Rampur, Chitwan, Nepal during 2012 from February to June. The area is located at 27^o 37' N latitude and 84^o 25' E longitude with an elevation of 228 meter above sea level. The soil type is sandy loam and climatically humid sub-tropical with average annual rainfall of 2000 mm (mainly during mid to late summer). A field experiment was conducted to observe some selected parameters such as, crop phenology, growth parameters, yield attributes, grain yield and biomass production. The study aimed to identify the appropriate genotype of maize under with and under various conservation agriculture based crop manage practices. Altogether 16 treatments consisting of four maize varieties namely; DMH849, Rajkumar, Manakamana-3 and Rampur Composite, and two levels of tillage, (i.e., conventional and no tillage, and two levels of residues management (i.e. with or without residue) were tested in 3 replication under split- split plot design. The individual plot size was 16.2 m^2 with spacing: 60 cm ×30 cm between row to row and plant to plant respectively.

Maize seed was planted in each row with 2 seeds /hill and was maintained single plant per hill by thinning extra plants on 4th week of planting. The fertilizer dose was 120:60:40 kg NPK/ha along with 10 ton FYM/ha. Half dose of nitrogen, full dose of phosphorous (P_2O_5) and potash was applied at in planting time as a basal dressing along side the maize rows and remaining half dose of nitrogen was side dressed in two split doses half on knee high stage and half on tasseling stage. Two weeding cum inter cultures at 22 and 42 DAS and two irrigation at knee high stage and grain filling stage was given. Carbofuran @ 2-3 granules per plant against stem borer was applied at knee high stage.

Observations were taken on, weather data during the crop season and soil samples were taken by tube auger from 0 to15 cm depth of soil layer before sowing of the seeds from each replication and composite sample was made and analyzed for the initial fertility status of the soil to determine organic matter content, organic carbon content, total N content, available P_2O_5, K_2O content and PH. Similar soil analysis were done after harvest the crop from each treatments. The phenological observations such as; emergence, plant population/m^2, days of tasseling, days of silking, days of physiological maturity were recorded. Biometric observation such as; number of leaf, leaf area index (LAI), plant height and dry matter accumulation were also recorded. Yield attributing characters such as; number of harvested ears,ear length and circumference,number of kernels per ear, thousand grain weight (TGW) or test weight: shelling percentage, grain moisture content (%), grain yield, Stover yield, harvest index and grain: stover ratio were recorded. After harvesting of cobs from each plot was weight through electrical balance and tabulated as grain yield/ha by using standard formula was workout then data were analyzed. All maize stems were harvested from the base from the net harvested area and weighted immediately after harvesting. Husk is also included while taking Stover yield. Stover yield was calculated on hectare basis in Kg/ha. Finally, the economic analysis such as; cost of cultivation, gross return (total economic yield in kg X market price in Rs. per kg), net return (gross return-total cost) and B: C ratio (gross income /Total cost) was worked out. Statically all parameters were analyzed for the variance by using MSTATC statistical package.

3. Results and Discussion

3.1. Phenological Observation

3.1.1. Plant Density Per Hectare

The result showed that the effect of tillage, and their interaction effect on number of plants /ha at harvest were found non significant but only the effect of residue, and variety was found significant (Table 1). The number of plants/ha was found to be 52240 in residue removed followed by 50231 plants/ha in residue left field. The effect of variety DMH849 was observed significantly more no of plants 53395.06 /ha followed Manakamana-3 having 53240.74 plants/ha as compared to the two varieties Rajkumar and Rampur composite.

Table 1. Interaction effects of varieties with each two levels of tillage and residue on plant population/ha at NMRP, Rampur 2012

S. N.	Treatment	Tillage		Residue	
	Variety	Tillage	No Tillage	Residue	No Residue
1	DMH-849	53395	53395	52778	54012
2	Rajkumar	53395	49691	51453	51543
3	Rampur Composite	48765	48765	45062	52469
4	Manakamana-3	53704	52778	51543	54938
	Mean	51736		51725	
	F-test(>0.05)	NS		NS	
	Standard Error (SE)	1404		1404	

NS = Not significant

3.1.2. Days to Tasseling

Days to tasseling was recorded from tassel emergence to 50% of plant have tasseled in each plot.

The effect of residue on days to tasseling was found significant result, where, days to tasseling was found slightly more in plots with residue (81.46 days) as compared to without residue (79.13 days). The effect of genotypes on days to 50% tasseling was highly significant. The variety DMH849 was found earlier (76 days) as compared to other three varieties, in which tasseling days ranged from 80 to 83 days and were statistically at par. The interaction effect between tillage, residue and variety was not significant (Table 2).

Table 2. Mean effect of tillage, residue and varieties on tasseling, silking and maturity at NMRP Rampur, spring season, 2012

Treatments	Time (DAS)		
	Tasseling	Silking	Maturity
Factor : B			
1. plant residue	81.46^{a}	85.54^{a}	121.37^{a}
2. Without residue	79.13^{b}	82.79^{b}	119.04^{b}
Mean	80.29	84.17	120.21
F-test(<0.01)	*	**	**
$LSD_{0.05}$	1.595	1.547	0.6919
Factor : C			
1. DMH-849	76.17^{b}	81.75^{c}	118.08^{c}
2. Rajkumar	80.58^{a}	83.92^{b}	122.50^{a}
3. Rampur Composite	81.42^{a}	85.08^{ab}	119.5b^{c}
4. Manakamana-3	83.00^{a}	85.92^{a}	120.75^{ab}
Mean	80.29	84.17	120.21
F-test (<0.01)	**	**	**
LSD	2.573	1.547	1.790
CV%	2.81	1.63	1.30

Means followed by the same letters within the same column and treatment are not significantly (P≤0.01 and P≤0.05) different according to Duncan's Multiple Range Test (DMRT), * = Significant at 5% probability, ** = Significant at 1% probability

3.1.3. Days to Silking

The silk exposed 1cm from closed ear was considered as emerged silk. The same rows as that of tasseling records were taken for days to silking. In this experiment, the effect of residue and variety on days to silking was found highly significant and the interaction between residues x variety was found significant. The duration of silking was found slightly longer residue left plot (85.5 days) as compared to residue removed plots (82.8 days). Rajkumar, Rampur Composite and Manakamana-3 were slightly late in silking duration that ranged from 85 to 86.7 days as compared to without residue condition (Table 2).

3.1.4. Days to Physiological Maturity

The appearance of black layer between ear surface and ear grains and occurrence of senescence of ear husks will be considered as an indication to physiological maturity.

The ANOVA revealed that the effect of residue and varietals were found highly significant difference. Under residue used condition, the maturity days slightly delayed (121 days) as compared to without residue condition (119 days). Where as in varietals effect, the variety DMH849 was found earlier in maturity days (118 days) followed by Rampur Composite (119 days). The interaction effect between tillage, residue and variety was not significantly differences (Table 3).

Table 3. Interaction effect of residue with genotypes on days to silking at NMRP, Rampur, spring season, 2012

Parameter	Days to 50 % silking	
Factor : C (Variety)	**Factor: B(Residue)**	
	With Residue	**Without Residue**
1. DMH-849	83.17^{b}	80.33^{c}
2. Rajkumar	86.00^{a}	81.83^{bc}
3. Rampur Composite	86.67^{a}	83.50^{b}
4. Manakamana-3	86.33^{a}	85.50^{a}
Mean	84.17	
F-test (<0.05)	*	
$LSD_{0.05}$	1.635	

Means followed by the same letters within the same column and treatment are not significantly (P≤0.01 and P≤0.05) different according to Duncan's Multiple Range Test (DMRT), * = Significant at 5% probability.

3.2. Biometric Observation

3.2.1. Leaf Area Index (LAI)

The leaves of a plant are normally its main organ of photosynthesis and the total area of leaves per unit ground area, called leaf area index (LAI), and it is an important biophysical descriptor of crop canopies.

In this experiment; randomly selected rows (from destructive row), 3 consecutive plants were sampled by cutting the plants at the soil line. Each plant was separated into leaf blades (including exposed portions of leaves in the whorl), stalks (including leaf sheaths) and ears. Then weighed immediately and the area of all leaves on a plant was measured with an optically scanning area meter (LI-

COR model LI-3000 with conveyor belt). All plant parts were dried to constant weight at 85° C for dry matter content of the samples.

Here, the effect of tillage on LAI was found significant at 45 DAS. The effects of residue were highly significant at 30 and 45 DAS and significantly different at 60 and 75 DAS. The varietals effect on LAI at 30 DAS was highly significant and significant at 75 DAS. The variety Manakamana-3 was found to be higher LAI ratio 0.066 followed by DMH849 (0.056) and Rampur Composite (0.055). The interaction effects of tillage x residue, tillage x variety and residue x variety were also found highly significant at 30 DAS (Table 4, Table 5, Table 7 and Table 8).

Table 4. Interaction effects of tillage x residue on Leaf Area Index (LAI) in 30 DAS at NMRP, Rampur, 2012

S. No	Parameter	LAI at 30 DAS	
	Factor: **A (Tillage)**	**Factor: B (Residue)**	
		Residue	No Residue
1	Conventional tillage	0.053^{c}	0.062^{b}
2	No tillage	0.043^{d}	0.07^{a}
	Mean	0.06	
	F-test(< 0.01)	**	
	$LSD_{0.05}$	0.0018	

Means followed by the same letters within the same column and treatment are not significantly (P≤0.01 and P≤0.05) different according to Duncan's Multiple Range Test (DMRT), ** = Significant at 1% probability, LAI = Leaf Area Index; DAS = Days after sowing

Table 5. Interaction effect between tillage x residue on Leaf Area Index (LAI) in 45 DAS at NMRP, Rampur, 2012

	Parameter	LAI in 45 DAS	
S.No	Factor**: A (Tillage)**	**Factor: B (Residue)**	
		Residue	No Residue
1	Conventional tillage	$0.481b^{c}$	0.701^{a}
2	No tillage	0.425^{c}	0.52^{b}
	Mean	0.53	
	F-test(< 0.05)	*	
	$LSD_{0.05}$	0.0717	

Means followed by the same letters within the same column and treatment are not significantly (P≤0.01 and P≤0.05) different according to Duncan's Multiple Range Test (DMRT), * = Significant at 5% probability.

Table 6. Interaction effects of tillage x Variety on LAI in 30 DAS at NMRP, Rampur, 2012

Factor A (Tillage)	LAI in 45 DAS			
	Factor C (Variety)			
	DMH-849	Rajkumar	Rampur Composite	Manakamana-3
Tillage	0.05^{f}	$0.055d^{e}$	0.054^{e}	0.071^{a}
No Tillage	0.063^{b}	0.046^{g}	0.056^{d}	0.061^{c}
Mean	0.06			
F-test	**			
$LSD_{0.05}$	0.0016			

Means followed by the same letters within the same column and treatment are not significantly (P≤0.01 and P≤0.05) different according to Duncan's Multiple Range Test (DMRT), ** = Significant at 1% probability.

Table 7. Interaction effects of residue x genotypes on LAI in 30 DAS at NMRP, Rampur, 2012

Parameter	**Leaf Area Index (LAI) at 30 DAS**			
Factor:B (Residue)	**Factor: C (Variety)**			
	DMH-849	Rajkumar	Rampur Composite	Manakamana-3
Residue	0.053^{e}	0.047^{f}	0.045^{g}	0.048^{f}
No Residue	0.06^{c}	0.055^{d}	0.066^{b}	0.084^{a}
Mean	0.06			
F-test(< 0.01)	**			
$LSD_{0.05}$	0.0016			

Means followed by the same letters within the same column and treatment are not significantly (P≤0.01 and P≤0.05) different according to Duncan's Multiple Range Test (DMRT), ** = Significant at 1% probability

Table 8. Interaction effects of tillage × residues × varieties on LAI in 30 DAS at NMRP, Rampur 2012

Parameter	**Leaf Area Index (LAI) at 30 DAS**			
	Tillage		**No Tillage**	
Variety (C)	**Residue**	**NoResidue**	**Residue**	**NoResidue**
DMH-849	0.05^{1h}	0.048^{i}	0.055^{g}	0.072^{c}
Rajkumar	0.06^{f}	0.051^{h}	0.034^{m}	0.059^{f}
Rampur Composite	0.046^{j}	0.062^{e}	0.043^{k}	0.069^{d}
Manakamana-3	0.055^{g}	0.087^{a}	0.041^{l}	0.08^{b}
Grand Mean	0.06			
F-test(< 0.05)	*			
$LSD_{0.05}$	0.0016			
CV%	10.04			

Means followed by the same letters within the same column and treatment are not significantly (P≤0.01 and P≤0.05) different according to Duncan's Multiple Range Test (DMRT), * = Significant at 5% probability.

Table 9. Effects of tillage and no tillage on plant height in different DAS at NMRP, Chitwan, 2012

Treatments	Plant height (cm)					Ear height (cm)	Plant height cm at maturity
	30DAS	45DAS	60DAS	75DAS	90DAS		
Factor: A							
Tillage	10.71^{a}	27.90	77.90	129.70	179.04	90.00	181.00
No tillage	9.25^{b}	25.70	65.30	116.50	169.70	88.33	174.13
Mean	9.9^{8}	26.80	71.60	123.10	174.37	89.17	177.57
F-test(< 0.05)	*	NS	NS	NS	NS	NS	NS
$LSD_{0.05}$	0.655						
Factor: B							
Residue	10.27	25.4^{b}	65.9^{b}	115.6^{b}	166.77^{b}	87.13	171.21b
No residue	9.69	28.2^{a}	77.3^{a}	130.7^{a}	181.98^{a}	91.21	183.92a
Mean	9.98	26.80	71.60	123.15	174.38	89.17	177.57
F-test(< 0.01)	NS	*	**	**	**	NS	*
$LSD_{0.05}$		2.608	9.795	14.88	12.49		8.443
Factor: C							
DMH-849	9.89^{b}	25.7^{b}	68.0^{b}	121.0	172.38	81.83^{b}	174.58
Rajkumar	9.7^{b}	25.0^{b}	71.2^{ab}	123.9	176.51	89.83^{a}	177.25
Rampur composite	9.11^{b}	26.4^{b}	70.9^{ab}	121.8	171.8	89.92^{a}	176.00
Manakamana-3	11.22^{a}	30.0^{a}	76.2^{a}	125.8	176.8	95.08^{a}	182.42
Mean	9.98	26.78	71.58	123.13	174.37	89.17	177.56
F-test(< 0.01)	**	**	**	NS	NS	**	NS
$LSD_{0.05}$	0.979	1.680	5.575			6.299	
CV%	9.46	6.92	8.18	6.71	5.91	6.39	5.26

Means followed by the same letters within the same column and treatment are not significantly (P≤0.01 and P≤0.05) different according to Duncan's Multiple Range Test (DMRT), * = Significant at 5% probability, ** = Significant at 1% probability, NS = Not significant.

3.2.2. Plant Height

Plant height was measured from the ground level to the top most visible due lap of five randomly selected plants from each plot at 30 DAS, 45 DAS, 60 DAS, 75 DAS, 90 DAS, and at maturity. The average plant height of maize crop recorded at various intervals under different level of factors. The analyzed result revealed that the effect of tillage practice has shown significant in30 days and the varietals effect was highly significant difference on plant height in 30, 45 and 60 DAS and rest intervals were non significant result.The variety Manakamana-3 was taller in height at maturity182.4 cm followed by Rajkumar (177.25 cm) Rampur composite (176cm).

3.2.3. Dry Mater Production

In general terms, Dry Matter (DM) refers to material remaining after removal of water, and the moisture content reflects the amount of water present in the vegetative part or feed ingredient. High production of total dry matter per unit area is the first prerequisite for high yield.

Table 10. Mean effect of tillage, residue and varieties of maize on DM (t/ha) in different days at NMRP, Rampur, 2012

Treatments	Dry matter content t/ha				
	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS
Factor: A (Tillage) Tillage	0.676	0.622	2.875	7.677	12.478
No tillage	0.753	0.486	1.728	6.171	10.614
Mean					
F-test(< 0.05)	NS	NS	NS	NS	NS
$LSD_{0.05}$					
Factor: B (Res.) Residue	0.646	0.406^{b}	1.954^{b}	6,684	11.414
No residue	0.783	0.702^{a}	2.649^{a}	7.164	11.678
Mean					
F-test(< 0.01) $LSD_{0.05}$	NS	** 0.1783	* 0.6046	NS	NS
Factor : C (Variety) DMH-849	0.593^{b}	0.484^{b}	1.799^{b}	5.897^{b}	9.995^{ab}
Rajkumar	0.649^{b}	0.461^{b}	2.306^{ab}	8.111^{a}	13.915^{a}
Rampur Composite	0.694^{b}	0.589^{ab}	2.348^{ab}	5.848^{b}	9.348^{b}
Manakamana-3	0.922^{a}	0.681^{a}	2.753^{a}	7.839^{ab}	12.926^{ab}
Mean	0.715	0.554	2.302	6.924	11.546
F-test(< 0.01) $LSD_{0.05}$	** 0.1805	* 0.1531	* 0.5583	** 2.111	** 72.14
CV%	22.07	32.95	28.80	26.69	30.40

Means followed by the same letters within the same column and treatment are not significantly (P≤0.01 and P≤0.05) different according to Duncan's Multiple Range Test (DMRT), * = Significant at 5% probability, ** = Significant at 1% probability, NS = Not significant

The effect of residue on DM at 45 and 60 DAS was highly significant where more DM was produced in without residue plot than the residue used plot.The statistical analysis result reveals that the effect of variety on DM production at 30 DAS was highly significant difference, where the variety Manakamana-3 produced higher DM (0.922 t/ha) and other three varieties were at par (Table 10). The variety Rajkumar produced higher DM 8.11t/ha and 13.91 t/ha at 75 DAS and 90 DAS respectively.

Table 11. Interaction effect between tillage x residue on DM in 30 DAS at NMRP, Rampur, 2012

Parameter	DM t/ha in 30 DAS	
Factor A (Tillage)	**Factor B (Residues)**	
	Residue	W/O Residue
Conventional tillage	0.741^{ab}	0.550^{b}
No tillage	0.611^{ab}	0.956^{a}
Mean	0.715	
F-test(< 0.01)	**	
$LSD_{0.05}$	0.3759	

Means followed by the same letters within the same column and treatment are not significantly (P≤0.01 and P≤0.05) different according to Duncan's Multiple Range Test (DMRT), ** = Significant at 1% probability.

Table 12. Interaction effect between tillage x variety on DM in 30 DAS at NMRP, Rampur, 2012

Tillage (A)	**Variety (C)**			
	DMH-849	Rajkumar	Rampur Composite	Manakamana-3
Tillage	0.490^{c}	0.810^{ab}	0.566^{bc}	0.836^{ab}
No tillage	0.695^{bc}	0.488^{c}	0.821^{ab}	1.007^{a}
Mean	0.714			
F-test(< 0.01)	**			
$LSD_{0.05}$	0.2553			

Means followed by the same letters within the same column and treatment are not significantly (P≤0.01 and P≤0.05) different according to Duncan's Multiple Range Test (DMRT), ** = Significant at 1% probability.

Table 13. Interaction effects between Residue x varietals on DM t/ha in 30 DAS at NMRP, Rampur, 2012

Residue	**Variety**			
	DMH-849	Rajkumar	Rampur Composite	Manakamana-3
Residue	0.713^{b}	0.627^{b}	0.634^{b}	0.608^{b}
No residue	0.472^{b}	0.672^{b}	0.753^{b}	1.235^{a}
Mean	0.714			
F-test(< 0.01)	**			
$LSD_{0.05}$	0.2553			

Means followed by the same letters within the same column and treatment are not significantly (P≤0.01 and P≤0.05) different according to Duncan's Multiple Range Test (DMRT), ** = Significant at 1% probability

3.2.4. Yield Attributing Characters

Khan *et al.* (2010), reported thatmulching practices also enhanced the number of ears/plant, ear height, length and diameter, tassel length, number of seed rows/ear and seeds/ row, 1000-grains weight, weight of rachis/ear, grain yield and higher harvest index (HI).

3.2.5. Number of Harvested Ears

Total number of ears harvested from net harvestable area was recorded as harvested ears per plot and it was converted to hectare basis as Number of ears per ha.

The effect of tillage, residue and all their interaction effects on Number of ears / ha were found non significant. Only the effect of genotypes was found highly significant different on the No of ears/ha. Higher no of ears/ha was found in Manakamana-3 (54013 ears/ha) followed by Rajkumar (53550 ears/ha).

3.3. Thousand Grain Weight (TGW) or Test Weight

Number of grain per row and 1000 grain weight were not influenced significantly by different tillage practices. Harvested maize cob collected from each plots was air dried and threshed separately then a samples and their average 1000 grains from each treatments was obtained and their weight was recorded by using electrical balance and expressed in gram (g). The kernels used for test weight was corrected to 15% moisture content. The effects of tillage, residue, genotype and their interactions on 1000 grain weight were non significant differences.

3.3.1. Biological and economic Yield

The economic and biological yields are interrelated. When the data of these two parameters are plotted on the same graph, it can be seen that the level of population at which biological yield reaches a plateau is the level of plant population at which maximum economic yield is obtained.

3.3.2. Grain Yield

Grain yield is determined by the yield attributes of crop. Grain yield is a function of various yield components primarily number of grain per ear, No of cob and 1000 grain weight etc.

Results revealed that the effects of tillage, residue and their interactions effects on grain yield were found non significant but the response of the genotypes were found highly significant differences on grain yield, where the hybrid variety, Rajkumar produced the highest grain yield (7182 kg/ha) followed by another hybrid DMH849 (4964 kg/ha). Among the OPVs Manakamana-3 was the highest yielder (6295 kg/ha) as compared to Rampur composite (4588 kg/ha).

3.3.3. Stover Yield

The effect of tillage and residue, interaction effect of tillage x variety, residue x variety and tillage x residue x variety on Stover yield were non significant. But the effect of genotypes on stover yield was found highly significant, where the highest stover yield was obtained from Rajkumar (9996.91 kg/ha) followed by Manakamana-3 (9825.62 kg/ha).

Table14. Mean effect of varieties on yield attributes at NMRP Rampur Chitwan, 2012

Treatments	No of ear/ha	No of grains/row	No. of grain/ear	Test wt (gm)	Grain yield (kg/ha)	Stover yield (kg/ha)	Biological yield (kg/ha)
Factor : C							
DMH-849	53086.67[a]	24.9[c]	340.51[c]	273.27	4955.85[b]	6763.89[b]	11719.74[b]
Rajkumar	53549.50[a]	34.9[a]	494.31[a]	265.71	7182.04[a]	9996.91[a]	17178.95[a]
R.Composite	45215.92[b]	25.2[c]	337.25[c]	282.76	4588.6[b]	6780.86[b]	11369.47[b]
Manakamana-3	54012.58[a]	27.6[b]	374.35[b]	281.71	6295.46[a]	9825.62[a]	16121.08[a]
Mean	53086.66	28.15	386.61	275.86	5755.49	8341.82	14097.31
F-test(<0.01)	**	**	**	NS	**	**	**
$LSD_{0.05}$	4568	2.148	28.33		983.2	1760	22.95
CV%	7.77	7.37	9.18	9.54	15.54	18.22	14.22

Means followed by the same letters within the same column and treatment are not significantly (P≤0.01 and P≤0.05) different according to Duncan's Multiple Range Test (DMRT), ** = Significant at 1% probability, NS = Not significant.

3.4. Harvest Index

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 statistical result revealed that the effect of tillage and interaction of tillage x residue had non significant differences on HI (0.4).

3.4.1. Grain: Stover Ratio

The grain: stover ratio was not affected by Tillage, residues, varietal and interaction of them. Statistically non significant results were observed for Grain: Stover (G: S) ratio in all the treatments.

3.4.2. Soil Moisture Analysis

The decrease in evaporation and the greater ability to store moisture under no-tillage produces a greater water reserve. This can often carry the crop through periods of short-term drought and avoid the development of detrimental moisture stresses in the plant. The more efficient use of soil moisture by no-tillage is reflected in higher corn yields (Blevins, 1971).

The effects of tillage on soil moisture at 45 DAS have no response, but the residue has significantly affected, where, the soil moisture under with residue has more soil moisture (15.29 %) as compared to without residue condition (12.91%). The interaction effect of tillage x varieties on soil moisture had highly significant differences, where the variety Rampur composite under conventional tillage and Manakamana-3 under without

tillage conditions had more soil moisture 15.36 and 15.25 % respectively at 45 DAS (Table 15).

Table 15. Effect of tillage, residue and genotypes on average soil moisture at 45 DAS at NMRP, Rampur, 2012

Treatments	Average Soil moisture (%)
Factor: A	
Tillage	14.19
Without tillage	14.01
Mean	14.10
F-test(< 0.05)	NS
Standard Error (SE)	0.397
Factor: B	
Residue	15.29[a]
Without residue	12.91[b]
Mean	14.10
F-test(< 0.05)	*
$LSD_{0.05}$	1.635
Standard Error (SE)	0.417
Factor : C	
DMH-849	14.30
Rajkumar	13.83
Rampur Composite	14.37
Manakamana-3	13.91
Mean	14.10
F-test(< 0.05)	NS
Standard Error (SE)	0.426
CV%	10.45

Means followed by the same letters within the same column and treatment are not significantly (P≤0.01 and P≤0.05) different according to Duncan's Multiple Range Test (DMRT), * = Significant at 5% probability, NS = Not significant.

2.4.3. Cost of Cultivation

Burning crop residue may reduce the soil organic matter and retaining crop residue is recommended for sustained productivity. Thus, because of the lower cost of seedbed preparation and more grain yield in reduced tillage. In double cropping system, decreasing tillage is very important due to limited time for seedbed preparation and to keep the production cost low. Cost of maize cultivation is the total expenditure incurred for growing maize. Total cost for general cultivation was calculated on the basis of local charges for different agro- inputs such as labor, fertilizer, compost and other necessary materials. Here the cost of cultivation was done based on performance of different variety of maize, under different conservation practices both for hybrid and open pollinated varieties at Rampur, Chitawan, Nepal during 2012.

2.4.4. Gross Return

Economic yield (grain and Stover) was converted into gross return (Rs/ha) on the basis of local market prices of maize grain and stover. The grain yield was calculated as per local price, i.e., Rs.22/kg grain and stover yield was calculated as per estimated Rs 1/kg stover. Gross return was calculated based on yields of grain and stover of hybrid and OPVs maize under different practices separately, i.e., conventional tillage with residues (CT+R), conventional tillage without residue (CT-R, no tillage with residue (NT+R) and no tillage without residue (NT-R) (Table 16).

2.4.5. Net return

The highest net return was fond form Hybrid variety Rajkumar under no tilled Vs residue used condition i.e. Rs. 105617/ha followed by without residue condition Rs. 92,267/ha. Among the OPVs, Manakaman-3 gave more net return under no tillage and without residue used condition Rs. 98,549/ha followed by conventional tillage and without residue (Rs.70,766/ha) Table 16).

2.4.5. Benefit: Cost Ratio

Among the two hybrids, variety Rajkumar has high benefit: cost ratio under both conventional tillage and no tilled conditions; however, the highest B:C ratio was found higher under no tilled and residue used condition (2.432) followed by no tilled and without residue used condition (2.382) respectively as compared to DMH849. Similarly, among the OPVs Manalapan-3 has highest B: C Ratio 2.651 under no tilled without residue used condition followed by no tilled and residue used condition (2.009) followed by Rampur composite (Table 16).

Table 16. Summary of cost of production, gross return, net return and cost: benefit (B:C) ratio on various cultivation practices and variety on hybrid and OPV maize during winter season, 2012

Particulars	Treatment/variety	Cultivation practices			
		CT+R	CT-R	NT+R	NT-R
Total cost (Rs)	DMH849 (Hybrid)	88379	81379	73779	66779
	Rajkumar (Hybrid)	88379	81379	73779	66779
	Rampur Composite (OPV's)	84734	77734	70134	63134
	Manakamana-3(OPV's)	84734	77734	70134	63134
Gross return (Rs	1 DMH849	117134	102366	120388	123294
	2 Rajkumar	177843	155717	179396	159046
	3 Rampur Composite	103683	133514	97519	96174
	4 Manakamana-3	146600	152900	145299	148483
Net return (Rs)	1 DMH849	28755	20987	46609	56515
	2 Rajkumar	89464	74338	105617	92267
	3 Rampur Composite	18949	55780	27385	33040
	4 Manakamana-3	61866	75166	75165	85349
B:C ratio	1 DMH849	1.325	1.258	1.632	1.846
	2 Rajkumar	2.012	1.913	2.432	2.382
	3 Rampur Composite	1.224	1.718	1.390	1.523
	4 Manakamana-3	1.73	1.966	2.072	2.352

CT= Conventional Tillage, NT= no tillage, +R = with residue, -R without residue.

4. Conclusion

Results revealed that the significant different on various parameters due to the effects of tillage, residue and variety. Here the highest no of ears in a hectare of land was found in Manakamana-3 (54013) followed by Rajkumar hybrid (53550). Higher the number of grains per ear was recorded under residue left plot with 406.04 followed by residue removed plots with 280.39 grains/ear. The significant differenceswere found due to genotype on shelling percent. Among the two hybrids; Rajkumar had the highest shelling % of 74.98 followed by DMH849 (74.57 %).

The effects of tillage, residue and their interactions on grain yield and stover yield were found non significant. However the response butthe response of the genotypes was found highly significant differences on grain yield and stover yield. Rajkumar hybrid produced the highest grain yield of7182 kg/ha followed by the Manakamana-3of 6295 kg/ha. Similarly, highest yield of stover was obtained in Rajkumar (9996.91 kg/ha) followed by Manakamana-3 (9825.62 kg/ha).

Biometric observations were recorded on leaf area index (LAI), plant height, and dry matter (DM) production. Variation on LAI due to tillage was found significant in 45DAS. Where as the effects of residue on LAI was found at 30, 45 60 and 75 DAS. Genotypic effects on LAI was found significant only at 30 DAS where Manakamana-3 had the highest LAI ratio of 0.066 followed by DMH-849 (0.056) and Rampur composite (0.055). The Rajkumar hybrid produced higher dry matter of 8.11t/ha at 75 DAS and 13.91 t/ha and 90 DAS respectively.

The variation due to tillage, residue and variety was evident for plant height in all the series. The variety Manakamana-3 was taller in height at maturity 182.4 cm followed by Rajkumar (177.25 cm) Rampur composite (176cm). The hybrid DMH849 had more grain to stover ratio 075 followed by Rajumar 0.74 as compared to Rampur composite.

Duration of days to tasseling was found significant on plot having with residue took 81.46 days to produce tassel than plot without residue 79.13 days. Crop duration of 121 and 119 days were recorded in both residue used and removed plots. Among the genotypes DMH849 was found earlier in maturity (118 days) as compared to other tested varieties

Economic analysis depicted that the highest net return was observed in Rajkumar Hybrid under no tilled with residue used condition of. Rs. 105617/ha followed by without residue condition (Rs. 92,267/ha). Manakaman-3 produced higher net return of Rs.85349/ha under no tillage with no residue used condition followed by conventional tillage with no residue (Rs.70,766/ha).The highest benefit cost ratio of 2.432) was found in plot having no tillage with residue (followed by no tilled with no residue (2.382) respectively. Manakamana-3 had the highest benefit cost Ratio 2.351 under no tilled with no residue used plots followed by no tilled with residues used plots (2.072).

Irrespective CA based practices Rajkumar hybrid and Manakamana-3 OPV were found to be superior during spring season under no tillage with residue in Terai region of Nepal. Significant reduction of production cost due to no tillage with residue over conventional tillage was recorded in the study. The similar experiment need to be further tested for one more season to verify the findings.

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