OPEN ACCESS

International Journal of Applied Sciences and Biotechnology

A Rapid Publishing Journal

ISSN 2091-2609

Available online at:

http://www.ijasbt.org

&

http://www.nepjol.info/index.php/IJASBT/index

Indexing and Abstracting

CrossRef, Google Scholar, Global Impact Factor, Genamics, Index Copernicus, Directory of Open Access Journals, WorldCat, Electronic Journals Library (EZB), Universitätsbibliothek Leipzig, Hamburg University, UTS (University of Technology, Sydney): Library, International Society of Universal Research in Sciences (EyeSource), Journal Seeker, WZB, Socolar, BioRes, Indian Science, Jadoun Science, Jour-Informatics, Journal Directory, JournalTOCs, Academic Journals Database, Journal Quality Evaluation Report, PDOAJ, Science Central, Journal Impact Factor, NewJour, Open Science Directory, Directory of Research Journals Indexing, Open Access Library, International Impact Factor Services, SciSeek, Cabell's Directories, Scientific Indexing Services, CiteFactor, UniSA Library, InfoBase Index, Infomine, Getinfo, Open Academic Journals Index, HINARI, etc.

CODEN (Chemical Abstract Services, USA): IJASKD

Vol-2(2) June, 2014

IC Value: **4.37**

SEM-Biotech Publishing

TB Karki1 et al. (2014) Int J Appl Sci Biotechnol, Vol 2(2): 185-192
DOI: 10.3126/ijasbt.v2i2.10353

ISSN (Online): 2091-2609
DOI Prefix: 10.3126/ijasbt

International Journal of Applied Sciences and Biotechnology (IJASBT)

Research Article

STUDIES ON THE CONSERVATION AGRICULTURE BASED PRACTICES UNDER MAIZE (ZEA MAYS L.) BASED SYSTEM IN THE HILLS OF NEPAL

Tika Bahadur Karki*[1], Nirmal Gadal[2] and Jiban Shrestha[1]

[1]Nepal Agricultural Research Council, National Maize Research Program, Rampur, Chitwan, Nepal
[2]CIMMYT, South Asian Regional Office, Kathmandu, Nepal

*Corresponding author email: tbkarki2003@gmail.com

Abstract

A farmer's field trial comparing the conservation tillage, where tillage was avoided and previous crops residues were kept and conventional tillage, where tillage was done and residues were removed from the field along with farmers practice of manual weeding and application of herbicides under maize-rapeseed based cropping system in the mid hills of Nepal was carried in collaboration with farmers during 2012 and 2013. Thus, three factors each having two levels was tested under randomized complete block design with five replications in each districts of Palpa and Gulmi. The effect of tillage methods and residue levels were not significant for yield and its' contributing traits of maize and test weight along with seed yield of rapeseed. However, it was evident in the second year. The effect of herbicide over farmer's practice of manual weeding on diameter and length of cob, test weight and grain yield of maize was obvious in both the years. The benefit cost ratio of 1.7 in conventional tillage with residue removed and 2.5 in no tillage with residue kept were recorded in the second year. Since, it reduced significantly the cost of production without severe yield penalties; farmers are interested to scale-up the conservation agricultural practices in the hills of Nepal.

Key words: Conservation agriculture, maize, herbicide, tillage, economics, residue, yield

Introduction

Maize (*Zea mays* L.) is the second most important staple food crop after rice in Nepal. The consumption of maize is 45.5 kg/capita/day as against 37.9 in wheat and 78.0 in rice in Nepal. Maize only contributes about 43.5 % of total edible food production in the country (ABPSD, 2012). However, the statistics shows that the contribution of maize to agricultural gross domestic production is only 6.88% as compared to 20.75% by rice and 7.14% by wheat (SINA, 2010). Furthermore, the importance of maize in Nepal has increased substantially in the past thirty years with maize area and production nearly doubling.

Maize is primarily used for human food in the hills and animal feed in Terai. Mid hills occupy about 70.42 % of the total maize area in Nepal. Similarly, in the hills farmers used to grow the short season crops like rapeseed also called tori in Nepal (*Brassica campestris* var. black toria) after the harvest of maize that utilizes the residual moisture of the previous season . Of the total area of rapeseed in Nepal, hill shares about 19 % with the average national productivity of 700 Kg ha^{-1} (MoAC, 2012). Similarly, average national productivity of maize in Nepal is 2.29 Mt ha^{-1} (MoAC, 2012). 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 demand less labor and reduce the cost of production in the hills of Nepal. Conservation agriculture (CA) system has been widely popular across the globe as one of the best alternative systems to conventional agriculture. Hence, by considering the above facts an experiment on CA under maize based system (maize-rapeseed) was carried -out in close collaboration with the farmers of Palpa and Gulmi, Nepal during the year 2012-13. The work was supported technically and financially by Hill Maize Research Project of CIMMYT, Nepal.

Materials and Methods

Experiments were conducted during 2012 and 2013 in Khaseuli, Palpa district (27°52′45″N and 83°28′20″E, 1450 meter above sea level) and Panitanki, Gulmi district (27°58′23″N and 83°23′48″E, 1350 meter above sea level.) in western Nepal. The experimental field had been double cropped with maize followed by rapeseed.

The soil in the experimental area is an un-irrigated with clay-loam soil, low in organic matter. The average maximum temperature was 26°C during the month of May and June and minimum was 6°C in January (Fig 1). Palpa district experiences an average annual rainfall of <1000 mm (Fig 2). Similarly, in Gulmi district the average maximum temperature of 26°C during the month of May and June and minimum of 6°C in January and annual rainfall of 1100 mm (Fig. 3 and 4).

Experimental design and treatments

A three-factorial experiment each having two levels (eight treatments) were tested with 5 replications in Palpa and Gulmi districts of Nepal. . It was designed to explore the influence of two tillage methods (conventional tillage, CT and no tillage, NT), two residue levels (residue kept and removed) and two weed management levels (manual weeding and Atrazine herbicide application). Fertilizers were applied @120: 60: 40 kg $NP_2O_5K_2O$ ha^{-1} for maize, of which full doses of $P_2O_5K_2O$ and 1/4th of N was applied during the maize planting and rest of the N was applied at 8 leaf stage, 14 leaf stage and at before tasseling. For rapeseed $NP_2O_5K_2O$ @ 60:40:30 Kg ha^{-1} were applied and of which $P_2O_5K_2O$ and 1/2 of N was applied during planting and remaining ½ at the time of pod bearing stage.

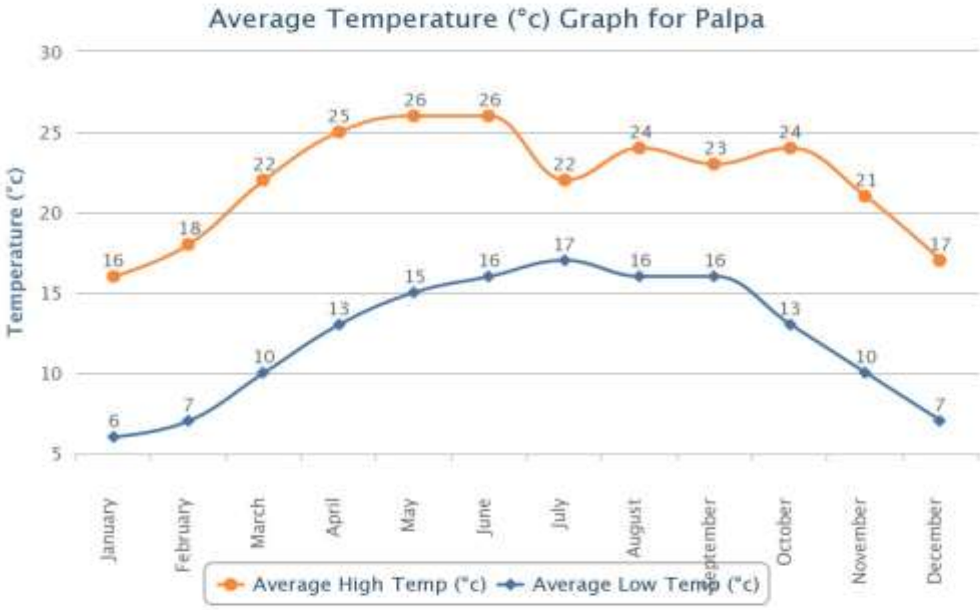


Fig. 1: Average maximum and minimum temperature of the experimental site in Palpa district.

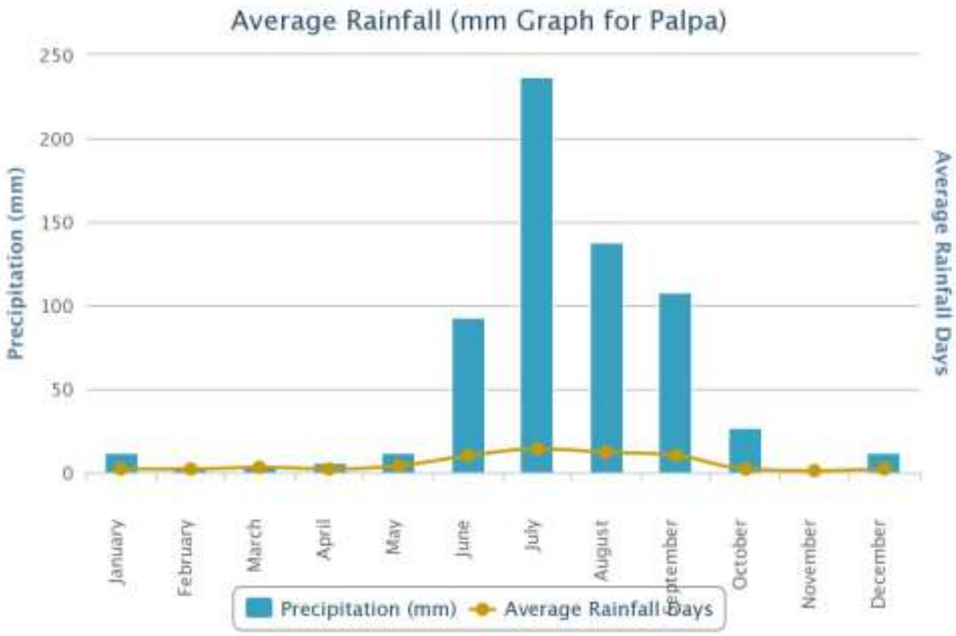


Fig. 2: Average rainfall (mm) of the experimental site in Palpa district

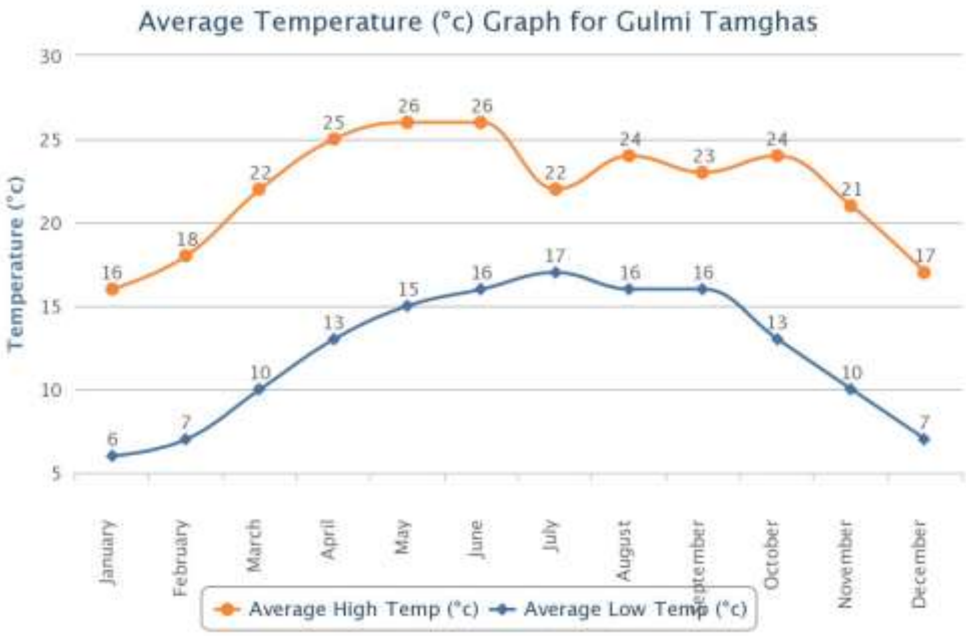


Fig. 3: Average maximum and minimum temperature of the experimental site in Gulmi district

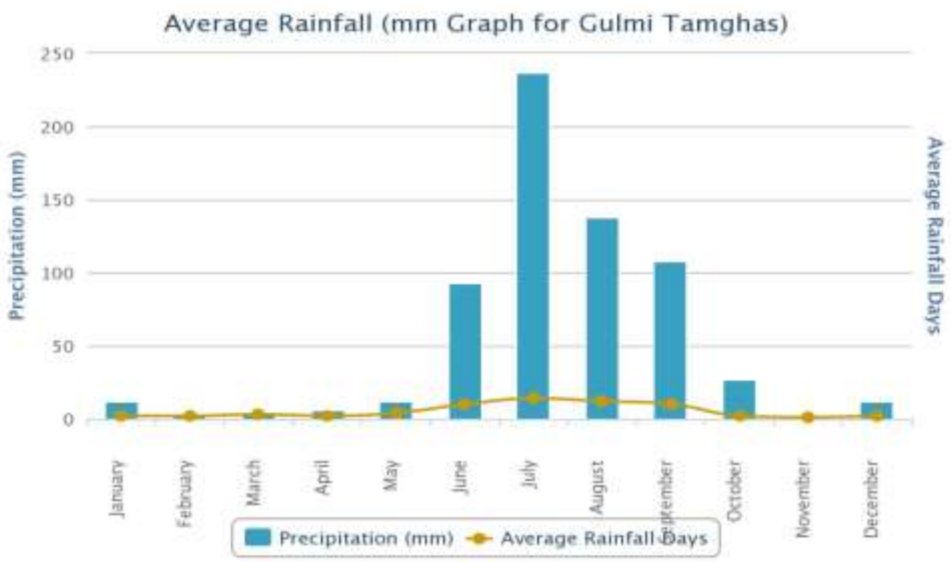


Fig. 4: Average rainfall days and total precipitation of the experimental site in Gulmi district

The plot size was of 5 m x 6 m i.e. 30 m^2. Manakamana-3 variety of maize and local variety of rapeseed was planted. Maize was planted with 60cm between rows and 25cm within row. Thus, 10 rows of 5m length i.e. 200 plants per plot were planted, whereas rapeseed was planted at 30 cm between rows and continuous seeding within row. In order to assure the adequate germination, 2-3 seeds $hill^{-1}$ were planted and thinned out to single plant per hill at 5 leaf stage of maize crop.

Observations were recorded for number of cobs per plot, field ear weight (kg per plot), cob length, cob diameter, grain moisture content (%), test weight (g) in maize and test weight along with seed yield for rapeseed. Similarly, the cost of production per plot and gross return and net benefit were also worked out and converted to hectare.

Results and Discussion

Test weight and seed yield of rapeseed

Variation due to location and tillage and interaction between location and tillage was found to be significant for test weight of rapeseed. Gulmi had the highest record of test weight over the Palpa. However, the effect of residue and weed management for test weight was not evident. Combined mean of both the years revealed that the test weight under no-tillage was higher over the conventional tillage (Table 1).

Table 1: Effects of tillage, residue and weed management on test weight and seed yield of rapeseed in the hills of Nepal, 2012-13

	Test wt (g)		Seed yield (kg ha^{-1})	
Treatment	Gulmi	Palpa	Gulmi	Palpa
CT + RK + Manual weeding	2.8	2.7	859.3	675.1
CT + RK + Herbicide	2.8	2.8	931.0	669.5
CT + RR+ Manual weeding	2.8	2.7	919.3	584.2
CT + RR + Herbicide	2.8	2.7	917.4	589.0
NT + RK+ Manual weeding	2.8	2.8	890.4	762.6
NT + RK + Herbicide	2.8	2.8	925.5	760.6
NT + RR + Manual weeding	2.8	2.7	847.1	574.7
NT + RR + Herbicide	2.8	2.7	881.7	599.8
Grand mean	2.8	2.7	898.0	653.1
Tillage (T)	**		**	
LSD	0.016		32.92	
Location (L)	**		**	
LSD	0.016		32.92	
TXL	*		**	
LSD	0.023		46.53	
CV%`	3.5		7.3	

**Significant at P=0.05; ** Significant at P=0.01, CT= Conventional tillage, NT= No tillage, RR= Residue removed, RK= Residue kept*

Seed yield

Similar to test weight, effect of tillage and location was evident for seed yield of rapeseed. Gulmi had the highest seed yield over Palpa and no tillage had the highest seed yield. Similarly, the interaction of location and tillage was also evident for seed yield (Table 1).

YIELD CONTRIBUTING PARAMETERS OF MAIZE

Plant population

Combined plant population at harvest was not affected by tillage, residue and weed management methods (Table 2). The plant populations of maize among tillage methods was not significantly different as reported by Sornpoon and Jayasuriya (2013). Similarly, they have also mentioned that the residue management did not show any significant effect on the plant population of maize in Thailand. It was evident due to location and was higher in Gulmi than in Palpa. Interaction of tillage and location for plant population also varied significantly (Table 3).

No of ears per hectare

Effect of tillage methods and residue levels on number of ears was significant and was higher in no tillage than in conventional tillage. Highest number of ears per hectare was recorded under no tillage and residue kept plots. However, the effect was not evident due to weed management methods (Table 2). Effect was also evident due to location and year. Higher number of ears was recorded for Gulmi compared to Palpa and in the year 2013 than in the year 2012. It might be due to the cumulative effect of residue and higher and uniformly distributed rainfall during the year 2013 (Table 3).

No of grains per ear

Tillage methods, residue levels and weed management methods affected the no. of grains per year in maize. Effect was also evident due to location and year. It was higher under no tillage; residue kept and weeds control by herbicides (Table 2). Similarly, the higher number of grains was recorded in Gulmi and in the year 2013 (Table 3). Interaction effect of tillage and location, tillage and year, location and year, residue, location and year on number of grains per ear was also evident (Table 3).

No of kernel rows per cob

No of kernel rows per cob also varied due to tillage methods and residue levels, but did not vary due to weed management methods. Similarly, difference was observed due to year but not due to location. No tillage, residue kept plot had higher number of kernels rows per cob during the year 2013 (Table 2 and 3). Interaction of tillage and year, tillage and location and location and year was also evident for it (Table 3).

Table 2: Combined effects of tillage, residue and weed management on yield contributing parameters of maize in the western hills of Nepal, 2012-13

Treatment	Plants at harvest ('000 ha^{-1})	No of ears ha^{-1}	No of grains row^{-1}	No of kernel rows cob^{-1}
Tillage methods				
CT	51.609	50.139	27.8	13.8
NT	51.424	52.431	29.69	14.3
LSD (T)	NS	517	0.63	0.13
Residue management				
RR	50.972	48.889	25.26	13.8
RK	52.06	53.681	32.23	14.4
LSD (R)	NS	1035	2.87	0.13
LSD (TxR)	NS	NS	NS	0.19
Weed management methods				
Manual	51.551	51.111	28.5	14.1
Herbicide	51.481	51.458	28.98	14.1
LSD (W)	NS	NS	0.36	NS

NS=Non significant

Table 3: Effect of tillage, residue and weed management on yield parameters of maize in the western hills, 2012-13

Treatment	**Plant stand at harvest ('000)**	**No of ears ha^{-1}**	**No of grains row^{-1}**	**No of kernel rows cob^{-1}**
Location				
Palpa	51.33	50.66	27.75	14.1
Gulmi	51.7	51.91	29.73	14.1
LSD (L)	234.5	632	0.36	NS
LSD (TxL)	366.5	679	0.5	0.18
Year				
Year 2012	51.57	49.583	28.23	13.8
Year 2013	51.46	52.986	29.25	14.4
LSD (Y)	NS	632	0.36	0.13
LSD (TxY)	NS	679	0.5	0.18
LSD (LxY)	331.6	893	0.52	0.18
LSD (TxRxL)	NS	NS	2.39	NS
LSD (RxLxY)	NS	1120	2.35	NS
LSD(TxLxY)	473.5	NS	NS	NS
Grand mean	51.52	51.285	28.7	14.1
CV,%	7.2	9	3.2	2.3

NS=Non significant

Cob Diameter and Length

Significant variation was observed due to tillage methods, residue levels and weed management methods for cob diameter and length. These were also affected due to year. Higher diameter and diameter of cobs was recorded in no tillage, residue kept and manual weeded plots, but the effect of no tillage, residue kept herbicide applied plots was higher for cob length as compared to conventional tillage, residue removed and manual weeding plots.

Significantly higher diameter of cob was found in Palpa than in Gulmi and in the year 2013 than in 2012. However, the effect was more in Gulmi than in Palpa for cob length. Interactions were significant due to tillage and residue, tillage and location, tillage and year, residue and year, location and year, tillage, residue and location and tillage, location and year (Table 4 and 5).

Grain Yield

Variation in grain yield of maize was observed due to year and during the year 2013 it was higher than 2012. It might be due to the effect of organic matter build-up and uniformly distributed rainfall in both the locations. Locational effect was also evident for grain yield and was higher in Gulmi than in Palpa. It might be due to the longer cob length in Gulmi thereby accommodating more grain per cob. Interactions were also affected significantly due to tillage x residue, location x year, tillage x residue x location, residue x location x year and tillage x residue x year (Table 4 and 5).

Table 4: Effects of tillage, residue and weed management on yield parameters and grain yield of maize in the hills of Nepal, 2012-13

Treatment	Cob diameter (cm)	Cob length (cm)	Grain yield (Mt ha^{-1})	Test wt (g)
Tillage methods				
CT	4.932	14.6	4.752	262.5
NT	5.197	15.8	5.212	263.9
LSD (T)	0.21	0.38	0.795	0.79
Residue management				
RR	4.675	14.4	3.887	261.4
RK	5.454	16.1	6.076	265.1
LSD (R)	0.19	0.38	3.275	3.28
LSD (TxR)	0.18	0.54	0.432	0.43
Weed management				
Manual	5.031	14.8	4.908	262.6
Herbicide	5.098	15.6	5.056	263.8
LSD (W)	0.05	0.38	3.05	3.05
LSD (TxW)	NS	NS	NS	NS
LSD (RxW)	NS	NS	NS	NS
LSD (TxRxW)	NS	NS	NS	NS

NS=Non significant

Table 5: Effects of tillage. Residue and weed management on yield parameters and grain yield of maize in the hills of Nepal, 2012-13

Treatment	Cob diameter (cm)	Cob length (cm)	Grain yield (Mt ha^{-1})	Test wt (g)
Location				
Palpa	5.389	14.9	4.735	263.2
Gulmi	4.739	15.52	5.228	263.2
LSD (L)	0.05	0.38	0.432	NS
LSD (TxL)	0.17	NS	0.61	NS
Year				
Year 2012	4.932	14.9	4.593	262.5
Year 2013	5.197	15.5	5.371	263.9
LSD (Y)	0.05	0.38	0.432	263.24
LSD (TxY)	0.17	NS	0.629	NS
LSD (RxY)	0.15	NS	NS	NS
LSD (LxY)	0.17	NS	0.61	NS
LSD (TxRxL)	0.18	0.77	2.7	NS
LSD (RxLxY)	0.15	NS	2.67	NS
LSD (TxRxY)	NS	0.77	0.848	NS
LSD (TxWxY)	NS	0.77	NS	NS
LSD (RxWxY)	NS	0.77	NS	NS
Grand mean	5.06	15.25	4.982	263.2
CV,%	2.6	6.3	4.982	4

NS=Non significant

Crop rotations can break soil pathogen cycles and reduce weed pressure (Karlen *et al*., 1997), and reduced tillage practices combined with crop residue retention on the soil surface can increase moisture infiltration (Arshad, 1999; Shaver *et al*., 2007), reduce erosion and increase water use efficiency (Johnston *et al*., 2002; McGarry, 2002). The removal of stover in marginally dry years showed a tendency to result in lower grain yields (Linden *et al*., 2000). Crop residues accumulating on the soil surface form a barrier to water loss by evaporation, decrease soil temperatures

Test Weight

Test weight was not affected by tillage, residue and weed management methods, however was affected due to year and was higher in the second year of 2013. It is evident with Fig 5 that there was a perfect positive correlation of test weight with grain yield of maize (r=0.96).

Economic analysis

Conservation tillage with residue performed better to conventional tillage without residue in terms of saving cost, gross return, net return and benefit cost ratio (Table 6). It might be due to the lower labor costs for land preparation and intercultural operations in NT than in CT, but the economic yields were similar in both the tillage methods. Similar was the findings of Tebrügge and Böhrnsen, (1997), and depicted that wages, fuel and repair costs were 84, was 85 and 65% lower in NT than in CT.

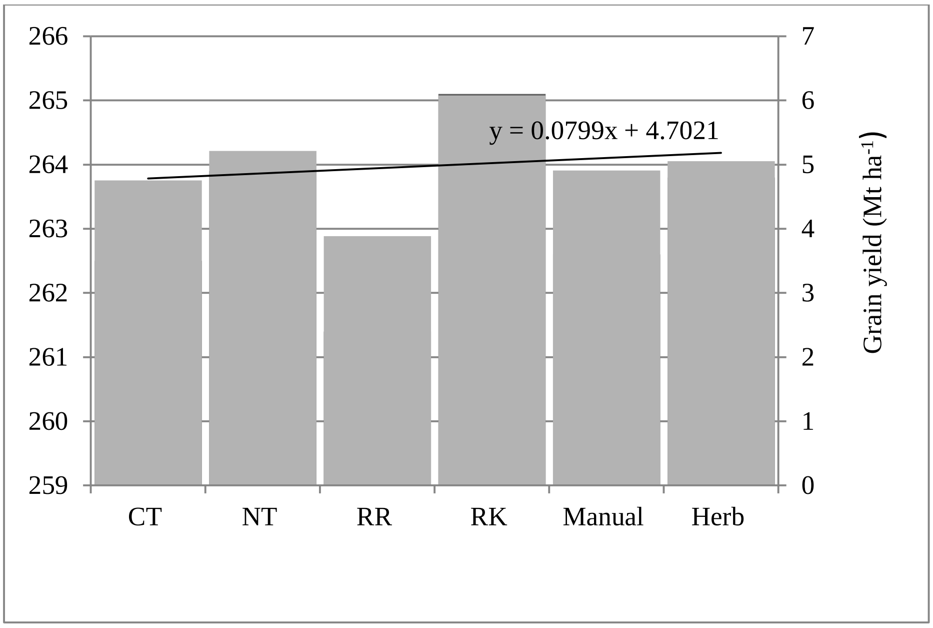
Conclusion

Length and diameter of cob, test weight and grain yield of maize was affected by tillage practices, residue and weed management. Similarly, the effect of tillage was obvious for test weight and seed yield of rapeseed. The benefit cost ratio of 1.7 in conventional tillage with residue removed and 2.5 in no tillage with residue kept were recorded in the second year. Similar participatory experiments need to be further tested and verified across the mid-hills of Nepal.

Acknowledgement

The study was only possible due to the financial and technical support of Hill Maize Research Project of CIMMYT, Nepal. Nepal Agricultural Research Council (NARC) and National Maize Research Program (NMRP) provided the research friendly environment and farmers of Western hills collaborated effectively in implementing the on-farm trials

.



Herb=Herbicide

Fig. 5: Correlation between test weight and grain yield of maize as affected by tillage, residue and weed management practices in the hills of Nepal

Table 6 Economics of maize- rapeseed cropping system as affected by tillage, residue and weed management in the hills of Nepal, 2012-13

Crop management methods	Total Cost (NRs ha^{-1})	Gross return (NRs ha^{-1})	Net return (NRs ha^{-1})	Benefit cost ratio
Conventional tillage without residue	84480	226300	141820	1.7
Conservation tillage with residue	67650	238760	171110	2.5

.

References

ABPSD (2012) Agri-Business Promotion and Statistics Division. Ministry of Agriculture and Co-operative. Singhadurbar, Kathmandu Nepal.

Arshad MA, Franzluebbers AJ and Azooz RH (1999) Components of surface soil structure under conventional and no-tillage in Canada. Soil Till. Res. 53, 41–47. DOI: 10.1016/S0167-1987(99)00075-6

Johnston AM, Clayton GW, Wall PC and Sayre KD (2002) Sustainable cropping systems for semiarid regions. In: Paper presented at the International Conference on Environmentally Sustainable Agriculture for Dry Areas for the 2nd Millennium, Septemb119, 2002, Shijiazhuang, Hebei Province, PRC.

Joshi KD, Conry C and Witcombe JR (2012) Agriculture, seed, and innovation in Nepal: Industry and policy issues for the future. Project Paper. International Food Policy Research Institute. www.ifpri.org.

Karlen DL, Mausbach MJ, Doran JW, Cline RG, Harris RF and Schuman GE (1997) Soil quality: A concept, definition, and framework for evaluation. Soil Science Society of America Journal 61, 4-10. DOI: 10.2136/sssaj1997.03615995006100010001x

Linden DR, Clapp CE and Dowdy RH (2000) Long-term corn grain and stover yields as a function of tillage and residue removal in east central Minnesota. Soil & Tillage Research, 56:167-174. DOI: 10.1016/S0167-1987(00)00139-2

McGarry (2002) Conservation agriculture practices for sustainable cotton production through improved soil structure and increased water use efficiency. In: Paper presented at the International Workshop on Conservation Agriculture for Sustainable Wheat Production in Rotation with Cotton in Limited Water Resource Areas, October 14–18, 2002, Tashkent, Uzbekistan.

MoAC (2012) Ministry of Agriculture and Co-operatives, Government of Nepal, Singhadurbar, Kathmandu Nepal.

Shaver GR, Billings WD, Chapin FS Giblin AE, Nadelhoffer KJ, Oechel WC and Rastetter EB (1992) Global change and the carbon balance of Arctic ecosystems: BioScience, v. 42, no. 6, p. 433–441. DOI: 10.2307/1311862

SINA (2010) Selected Indicators of Nepalese Agriculture and Population. Ministry of Agriculture and cooperatives, Agri-business Promotion and Statistics Division, Kathmandu, Nepal

Sornpoon W and Jayasuriya HPW (2013) Effect of different tillage and residue management practices on growth and yield of corn cultivation in Thailand. Agric Eng Int: CIGR Journal Open access at http://www.cigrjournal.org Vol. 15, No.3.

Tebrügge F and Böhrnsen A (1997) Crop yields and economic aspects of no-tillage compared to plough tillage: Results of long-term soil tillage field experiments in Germany. In: Tebrügge and Böhrnsen (eds) Proceedings of the EC-Workshop-IV-Boigneville; Experience with the Applicability of No-Tillage Crop Production in the West-European Countries. Wissenschaftlicher Fachverlag, Giessen, Germany, pp 25-43.