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Original Research Article

Systems optimization through tillage and residue management and cropping system in maize based system

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Keywords

Maize,
Tillage,
Residue,
Cropping system and
Grain yield

A B S T R A C T

With the aim of optimizing the maize based system under various crop management practices, an experiment was carried-out at National Maize Research Program, Rampur, Chitwan Nepal during 2013 and 2014. The experiment was laid-out in strip-split plot design with three factors, of which tillage as vertical factor having two levels of CT (Conventional tillage) and NT (No tillage). The horizontal factor was residue with two levels of RR (Residue removed) and RK (Residue kept. Similarly in sub-sub plot factor cropping system with two levels of maize + soybean-wheat and maize sole-wheat was tested. Significantly the earliest emergence of tasseling was observed in NT with 66.17 days as against 68.08 days in CT. The plant height of maize was significantly higher in CT (237.19 cm) than in NT (229.16 cm). The highest number of lodged plants was recorded in CT (1493 plants) than in NT (972 plants ha^{-1}). The highest test weight of 132.42 g per 500 grains was recorded in NT than 131.87 g per 500 grains in CT. [1] The highest system yield was recorded in the plot where tillage was omitted, residue was kept and intercropping of maize with soybean during summer and wheat during winter was followed. Therefore, farmers from Terai and inner Terai can adopt the conservation agriculture (no tillage with residue and crop rotation) based practices under maize-wheat system.

Introduction

Maize is the second most important staple food crop in Nepal. Its area, production and productivity is 8.49 million ha, 19.9 million Mg and 2. 3 Mg ha^{-1} (MoAD, 2013/14). It contributes about 25.02% in total cereal production, 6.54% in AGDP and 3.15% in GDP (MoAD, 2013). It plays an important role in national food security.
Soybean is grown in an area of 24933.9 ha with the production and productivity of 29220 Mg and 1172 Mgha^{-1} respectively.

Soybean is generally grown in the hills and is considered an ideal crop for intercropping with maize, comparative tolerance for shade and drought, efficient light utilization, utilizes space, time, nutrient and soil moisture more efficiently (Wright *et al*. 1988). Maize/soybean intercropping system is predominant in Western and South-western hills of Nepal (Prasad, 2003). Since, intercropping refers to growing of two or more generally dissimilar crops simultaneously on the sample piece of land, base crop necessarily in distinct row arrangement. Intercropping has been recognized as a potentially beneficial system of crop production system in tropical agriculture due to more efficient utilization of resources (Chaudhary and Rosario, 1992). Inclusion of legumes with cereals enables farmer to cope with erosion and declining level of soil organic matter and available nitrogen. In intercropping, cereal gets benefit through N transfer from legume (Giller and Wilson, 1991). Intercropping in maize not only gave higher production but also keep down weed growth, because of its smothering effect.

However, main cause of low production and productivity under intercropping obtained in developing country is due to improper crop arrangement with its attendant waste of environmental resources and wrong intra-specific mixture. Intensive tillage and removal of all the crop residues from the field are the common practices being practiced in maize based system in Nepal. Tillage is one of the important factors that influence soil properties and crop yields which contribute up to 20% of the crop production factors (Khurshid *et al.,* 2006). Conventional tillage system where large proportion of the operational cost is expended for tillage operation demands more labor under the burgeoning problem of labor scarcity and ever increasing wage rates. In addition, frequent tillage is also hazardous in environmental point of view as loose soil is prone to water and wind erosion. In the uplands of Inner Terai of Nepal, generally three or two crops of maize are grown in sequence ass summer, winter and spring season crop in a year. It is considered as unsustainable production system, since it mines the nutrients from the same depth of soil and harbors the pests and pathogens. Some studies on conservation tillage (CT) where crops are grown in no tilled field and crop residues are left in the field, reported that no tillage and reduced tillage could improve soil physical conditions and corn yield (Liang *et al.*, 2009).

Despite the significance of CT and intercropping of soybean with maize, information on intercropping of soybean with maize under no tilled and residue kept in the field are meager in Nepal. Therefore, it is imperative to generate knowledge on possibilities of intercropping maize with soybean under CT, their effect on soil properties and system's productivity . Considering the above facts, the study was carried out in the uplands of Inner terai of Nepal during the summer season of 2013 to winter 2014.

Materials and Methods

Experimental site

A two seasons experiment was incepted during the summer season of 2013 and completed on winter season of 2014 at National Maize Research Program, Rampur, Chitwan. The NMRP is located between 27° 39' 19.04'' N latitude and 84° 21' 28.098''E longitude and 612 ft msl. The first crop of maize received 105.66mm of rainfall followed by 2438.71 mm by second crop of rice, 306.4 mm by third crop of maize and 1313.4 mm by forth crop of rice. Similarly, the average highest maximum temperature during the first crop of maize was 30.98°C in May and the lowest maximum of 20.0°C in January. The highest average minimum temperature of 20.00°C in May and the lowest average minimum temperature of 7.23°C in January. The average relative humidity of 93.1% and 93.8 % respectively was recorded during the first crop maize the second crop of rice.

Similarly, the average highest maximum temperature during the second crop of rice was 34.4°C in June and the lowest maximum of 27.4°C in November. The highest average minimum temperature of 27.92°C was recorded in August and the lowest average minimum temperature of 4.48°C in November.

The experimental set up

The experiment was tested in strip-split plot design with three factors, of which tillage as vertical factor having two levels of CT (Conventional tillage) and NT (No tillage). The horizontal factor was residue with two levels of RR (Residue removed) and RK (Residue kept. Similarly in sub-sub plot factor cropping system with two levels of maize + soybean-wheat and maize sole-wheat was tested. Thus, altogether 8 treatments were tested in three replications. Plot size for each treatment was $24m^2$. Six rows of 4m length and row to row spacing of 100 cm and plant to plant i.e hill to hill spacing of 50 cm was maintained and in each hill two seeds of maize were planted. In between two rows of maize two rows of soybean spaced at 50 cm and within the row planting was done at 20 cm apart. Seed rate of 25 kg ha^{-1} for maize and 80 kg ha^{-1} for soybean was used.

Maize was fertilized with 120:60:40 NPK kg ha^{-1}. All of P and K and $1/3^{rd}$ of N were applied during planting and the remaining N was splitted into two, once at V7 stage and another at pre-tasseling stage. However, soybean was not fertilized separately.

Wheat was spaced at 20cm between rows and continuous seeding was done within the row. Twenty kg ha^{-1} of seed rate was applied for wheat. It was fertilized with 100:50:25 NPK kg ha^{-1}. Rest of the intercultural operations was done as and when needed. Soil samples was taken from each replication before land preparation and after the harvest of the soybean crop from the depth of 15 cm to determine soil pH, total nitrogen, available phosphorous, available potassium and soil texture along with bulk density.

Observations were recorded for crop phenologies like tasseling, silking and physiological maturity, grain yield and related parameters, stover yield, harvest index, plant and ear height, stalk lodging along with economics of production for maize, and days to physiological maturity in soybean, economics of production for maize along with yield parameters. Similarly, in wheat crop phenologies like heading and physiological maturity, crop yield parameters and economics of production were recorded. The yield of wheat and soybean were converted to maize grain yield equivalent yield (MGYEY) and systems yield (SY) was also derived.

Ms Excel for data recording and GenStat package for data analysis was used. If the result comes significant, DMRT (Duncan's Multiple Range Test) for mean separation at 5 % level of significance was performed. ANOVA was constructed with reference to Gomez and Gomez, 1984.

Results and Discussion

Days to tasseling

Except residue, tillage and intercrop affected the duration of tasseling in maize, on an average the crop took 67.12 days to attain the 75% tasseling. Significantly earliest emergence of tasseling was observed in NT with 66.17 days as against 68.08 days in CT. On an average the crop took 67.5 days for tasseling. Similar was the findings of Araus *et al*. (2008).

Days to silking

Except residue, tillage and intercrop affected the duration of silking in maize, on an average the crop took 71.12 days to attain the 75% silking. Significantly earliest emergence of silk was observed in NT with 70.12 days as against 72.08 days in CT. On an average the crop took 71.12 days for silking. Araus *et al*. (2008) also reported the similar findings of shorter duration for silking due to no tillage practice.

Days to maturity

Unlike the tasseling and silking, duration of crop maturity was only affected by tillage methods and significantly the shortest duration was taken by NT with 103.92 days as against the 104.92 days by CT. Average crop duration of Manakamana -3 was 104.17 days at Rampur during the summer season. Tillage did not affect the crop maturity in the similar experimental findings of Araus *et al*. (2008). Olesen *et al*. (2004) also mentioned that the rapid growth of the crop might have contributed to early maturity.

Plant height of maize

Maize in the experimental field attained the average height of 233.17 cm. Plant height of maize was not affected by residue and crop rotation systems, however was affected by tillage methods. The height of the maize plant was significantly higher in CT (237.19 cm) than in NT (229.16 cm). Iqbal *et al*. (2013) reported the shorter plant height of maize in NT compared to CT.

Ear height of maize

On an average ears were placed at 121.21cm above the ground and nearly half of the height of plant. Like in plant height, it was also influenced by tillage and was 117.66 cm in NT than 124.76 cm in CT. It was not varied due to residue and crop rotation. Since, plant height generally dictates the ear height and is correlated each other.

Number of cobs per hectare

Total number of cobs in a hectare was not influenced by tillage, residue and crop rotation. Due to uniform plant emergence and maintenance until harvesting produced almost the similar number of cobs per hectare at harvest. Since, the crop was planted during summer and hence no limitation of soil moisture was there and the other crop management practices were also applied accordingly. Many researchers have also depicted the similar results.

Lodging of the stalk

When the stalk has been permanently displaced from its perpendicular position and may be classified as root or stem lodging. Stalk lodging, by definition, is the breakage of the stalk below the ear. Severely lodged corn leads to increased harvest losses, increased harvest time, increased drying cost, and may result in volunteer corn the following year. Annual yield losses due to stalk lodging in the U.S. range between 5 and 25%. In addition to outright yield losses, grain quality may also decline as a result of stalk lodging. In our case, both stem and root lodging was observed. However recording was done in aggregate. High plant population often decrease the amount of light in the crop canopy making plants lean and thin, extreme soil moisture retard the development of root growth that cannot resist the above ground part of maize. Damage caused by maize cut worms and borers may also intensify the lodging in maize.

The effect of tillage methods on the severity of stalk lodging in maize was obvious and the significantly highest number of lodged plants was recorded in CT (1493 ha^{-1}) than in NT (972 ha^{-1}). However, residue and crop rotation had no effect on it. On an average 1233 plants ha^{-1} were lodged in the experiment. All of them were lodged in between 15 days after silking to physiological maturity. This may be attributed partly to the higher moisture contents and bulk densities existing under NT direct drilling of plants (Allen, 1981; Berry, Mallett & Johnston, 1985), which promote a more robust and extensive root system within the top 300 rnm of soil. This is particularly true on fine, well-structured soil in which the soil strength reaches an equilibrium level not restrictive to root growth (Allen, 1981).

Number of kernel rows per cob, kernels per row

Total number of grain rows per cob of maize was not influenced due to tillage, residue and crop rotation. However, the rows were higher in CT (12.17) over NT (11.33), with residue (12) over without residue (11) and maize sole (11) over maize + soybean (12). On an average 12.75 grain rows per cob was recorded in the experiment. Number of pernels per row was affected by tillage methods only, however was not affected by residue and crop rotation. On an average, 29.50 grains were recorded in a row. As such, kernel number is a function of photosynthesis at silking and it is closely related with plant growth rate during the critical period for kernel set (Edmeades and Daynard, 1979) and might have affected by higher soil moisture content in NT than in CT.

Test weight

Test weight of maize was evident due to tillage methods but not due to residue management and crop rotations. The highest test weight of 132.42 g per 500 grains was recorded in NT than 131.87 g per 500 grains in CT. On an average 132.15g of seed weight per 500 seeds were recorded from the experimental field. Interaction effect of tillage X crop rotation, residue X crop rotation and tillage X residue X crop rotation. Liang and Richards (2012) also depicted the higher test weight of maize under NT than in CT.

Grain and stover yield

Grain yield of maize was not affected by tillage, residue and crop rotation. However, the yield was higher in CT with 4252 kg ha^{-1} over NT with 4124 kg ha^{-1} with 4188 kg ha^{-1}. It might be due to the effect of uniform number of cobs per hectare among the tested treatments. Lesser number of non significant kernel rows might have affected the non-significant grain yield. Stover yield was also not affected by the tested treatments (Table 3). Rice *et al.* (1986) and Kapusta *et al.* (1996) also reported no differences in grain yield of maize with no-till and conventional tillage over time.

Aboveground Biomass

Above ground biomass was also in agreement with grain yield and did not vary with the tested treatments. Generally, the above ground crop biomass is directly related to grain yield. In the experiment average biomass was 9312 kg ha^{-1} (Table 3).

Effect on wheat (Second crop)

Plant height of wheat was significantly higher under CT (96.09cm) over NT (92.51cm), residue kept (95.07cm) over RR (93.52cm**),** however, the number of tillers m^{-2}(RK: 425.5 Vs. RR:421.0) and No of spikes m^{-2}(RK: 410.8 Vs. RR: 405.7) was only affected by residue management practices (Table 2). Number of spikelet's spike^{-1} and no of grains spike^{-1} however were not affected by tillage, residue management and crop roration system (Table 4).

Test weight, grain and straw yield, total above ground biomass and harvest index of wheat

Except residue management methods, tillage and crop rotation did not affect the test weight, grain and straw yield, total biomass and harvest index of wheat (Table 5). Test weight, grain and straw yield, total above ground biomass and harvest index of wheat were 36.08 g, 3.81 Mg ha^{-1}, 4.96 Mg ha^{-1}, 8.80 Mg ha^{-1} and 43.51%, respectively. Whereas in residue removed plots the test weight, grain and straw yield, total above ground biomass and harvest index of wheat were 34.67g, 3.51 Mg ha^{-1}, Mg4.64 ha^{-1}, 8.15 Mg ha^{-1} and 42.99%, respectively (Table 5 and Fig 1). However, Jat *et al*. (2009) reported from an experiment under rice-maize cropping system for four years that rice yield was similar in all planting/tillage systems (conventional tillage, permanent bed and no tillage) but the maize and system yields were highest with permanent beds followed by no tillage. In the permanent bed and NT treatments, the improved soil porosity and infiltration rate provides more favorable conditions for the upland crops (Jat et al, 2009). Whereas the in our case, the tillage and residue management systems under maize-wheat cropping system only for two seasons (one year) might not have affected the grain and system yields.

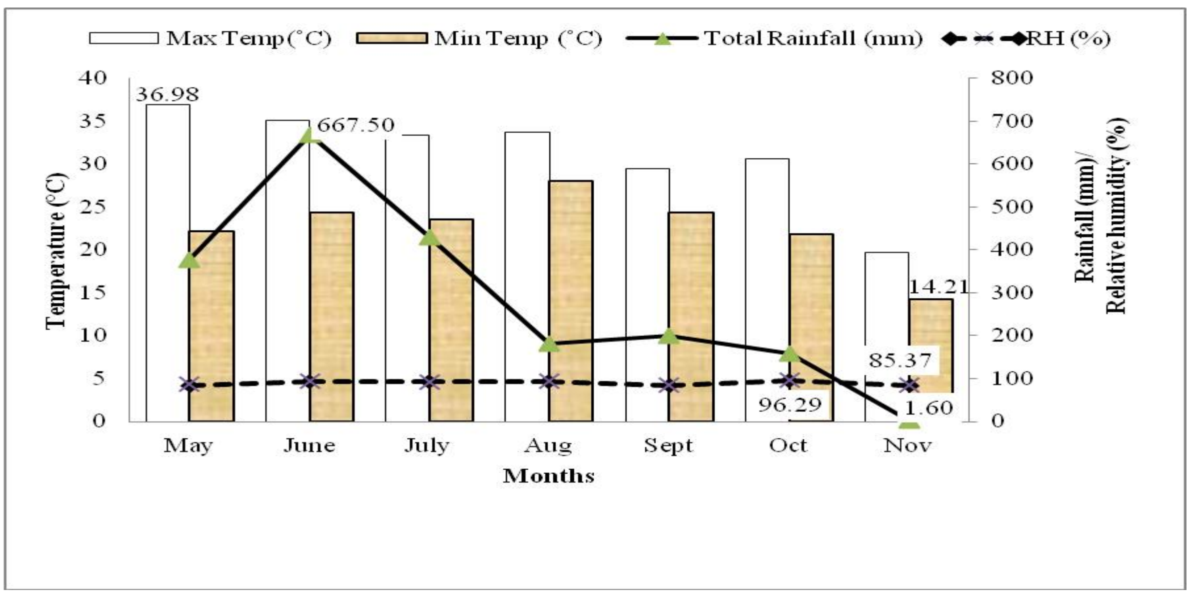

Fig.1 Weather data during the experimental period of maize and soybean intercropping, Rampur, 2013-2014

Table.1 Effect of tillage methods, residue management and crop rotation on crop phenology of maize during summer season, Rampur, 2013

Treatments	Days to tasseling	Days to silking	Days to maturity
Tillage methods			
NT	66.17	70.17	103.92
CT	68.08	72.08	104.92
F test	**	**	*
LSD	0.510	0.510	0.799
Residue management			
Residue kept	67.17	71.08	104.50
Residue removed	67.08	71.17	104.33
F test	NS	NS	NS
LSD	-	-	-
Cropping rotation			
Maize-Wheat	66.50	71.75	104.17
Maize+Soybean-Wheat	67.75	70.50	104.67
F test	**	**	NS
LSD	0.510	0.510	-
CV, %	3.7	2.8	3.9
Grand Mean	67.12	71.12	104.42

Table.2 Effect of tillage methods, residue management and crop rotation on plant and ear height and stalk lodging of maize, Rampur, 2013-2014

Treatments	Plant height (cm)	Ear height (cm)	No of cobs ha^{-1}	Stalk lodging plants
Tillage methods				
NT	229.16	117.66	45448	972
CT	237.19	124.76	45989	1493
F test	*	*	NS	*
LSD	3.697	3.12	-	288.4
Residue management				
Residue kept	232.96	121.21	45998	1111
Residue removed	233.38	121.21	45439	1354
F test	NS	NS	NS	NS
LSD	-	-	-	-
Crop rotation				
Maize-Wheat	232.04	119.99	45552	1181
Maize+Soybean-Wheat	234.30	122.43	45885	1285
F test	NS	NS	NS	NS
LSD	-	-	-	-
TxR	NS	NS	NS	*
LSD	-	-	-	134.5
CV, %	4.8	2.8	2.5	26.7
Grand Mean	233.17	121.21	45718	1233

Table.3 Effect of tillage methods, residue management and crop rotation on grain yield, yield contributing traits, stover yield and harvest index of maize, Rampur, 2013-2014

Treatments	No of kernel rows cob^{-1}	No of kernels row^{-1}	Test weight (g)	Grain yield (Mg ha-1)	AGB (Mg ha^{-1})	Stover Yield (Mg ha^{-1})	Harvest Index (%)
Tillage methods							
NT	11.33	28.08	132.42	4.124	9.200	5.076	44.79
CT	12.17	30.92	131.87	4.252	9.424	5.172	45.07
F test	NS	*	*	NS	NS	NS	NS
LSD	-	1.604	0.438	-	-	-	-
Residue management							
Residue kept	12	29.83	132.22	4.349	9.620	5.270	45.18
Residue removed	11.5	29.17	132.07	4.027	9.004	4.977	44.68
F test	NS	NS	NS	NS	NS	NS	NS
LSD	-	-	-	-	-	-	-
Crop rotation							
Maize-Wheat	12	29.58	131.94	4.064	9.590	5.277	44.92
Maize+Soybean-Wheat	11.5	29.42	132.35	4.313	9.035	4.971	44.94
F test	NS	NS	NS	NS	NS	NS	NS
LSD	-	-	-	-	-	-	-
CV, %	6.2	6.2	2.4	12.9	11.9	11.2	3.9
TxCR	NS	NS	*	NS	NS	NS	NS
LSD	-	-	0.62	-	-	-	-
RxCR	NS	NS	*	NS	NS	NS	NS
LSD	-	-	0.62	-	-	-	-
TxRxCR	NS	NS	*	NS	NS	NS	NS
LSD	-	-	0.62	-	-	-	-
Grand Mean	11.75	29.5	132.15	4.188	9.312	5.124	44.93

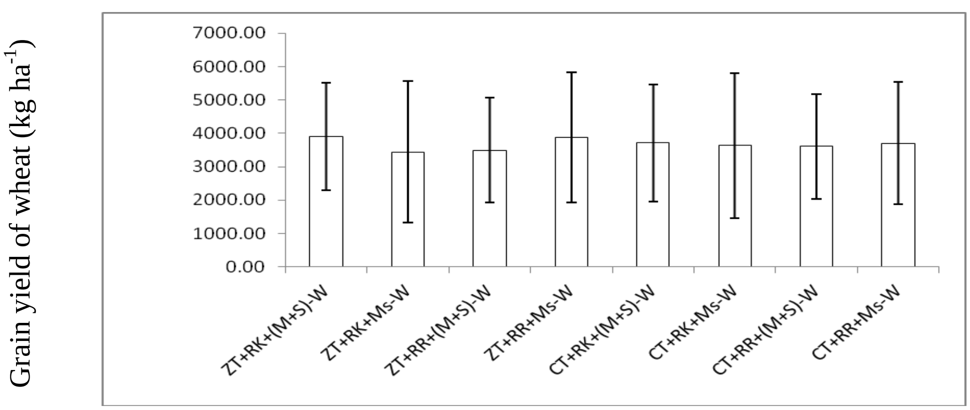

Fig.2 Effect of tillage methods, residue management and crop rotation on wheat grain yield along with standard deviation, Rampur, 2013-2014.

Table.4 Effect of tillage methods, residue management and crop rotation on plant height and yield contributing traits of wheat, Rampur, 2013-2014.

Treatments	Plant height (cm)	No of tillers m^{-2}	No of spikes m^{-2}	No of spikelets $spike^{-1}$	No of grains $spike^{-1}$
Tillage methods					
NT	92.51	423.42	408.25		25.42
CT	96.09	423.08	408.25	32.58	25.5
F test	**	NS	NS	NS	NS
LSD	0.431	-	-	-	-
Residue managment					
Residue kept	95.07	425.5	410.83		25.12
Residue removed	93.52	421	405.67	32.75	25
F test	**	**	*	NS	NS
LSD	0.431	2.439	1.52	-	-
Crop rotation					
Maize-Wheat	94.37	423.17	407.92		25.75
Maize+Soybean-Wheat	94.23	423.33	408.58	32.5	25.17
F test	NS	NS	NS	NS	NS
LSD	-	-	-	-	-
CV, %	3.6	3.5	3.4	4.3	5.2
TxR	*	NS	NS	NS	NS
LSD	0.609	-	-	-	-
Grand Mean	94.3	423.25	408.25	32.75	25.46

Table.5 Effect of tillage methods, residue management and crop rotation on test weight, grain and stover yield, total biomass and harvest index of wheat, Rampur, 2013-2014

Treatments	Test wt (g)	Grain yield (Mg ha-1)	Straw yield (Mg ha-1)	Total biomass (Mg ha-1)	Harvest index (%)
Tillage methods					
NT	35.25	3.65	4.78	8.44	43.23
CT	35.5	3.69	4.828	8.52	43.26
F test	NS	NS	NS	NS	NS
LSD	-	-	-	-	-
Residue management					
Residue kept	36.08	3.81	4.96	8.80	43.51
Residue removed	34.67	3.51	4.64	8.15	42.99
F test	*	*	*	*	*
LSD	0.82	0.22	0.31	0.441	0.35
Crop rotation					
Maize-Wheat	35.25		4.83	8.53	43.27
Maize+Soybean-Wheat	35.5	3.65	4.77	8.426	43.23
F test	NS	NS	NS	NS	NS
LSD	-	-	-	-	-
CV, %	2.6	7	5.2	5.9	2.1
Grand Mean	35.38	3.67	4.79	8.479	43.25

Table.6 Effect of tillage methods, residue management and crop rotation on system yield Rampur, 2013-2014

Treatment	System Yield (Mg ha^{-1})
ZT+RK+(M+S)-W	11.29
ZT+RK+Ms-W	8.21
ZT+RR+(M+S)-W	10.31
ZT+RR+Ms-W	7.59
CT+RK+(M+S)-W	11.25
CT+RK+Ms-W	8.30
CT+RR+(M+S)-W	10.37
CT+RR+Ms-W	7.73
SEm (±)	0.358
$LSD_{0.05}$	1.085**
CV, %	6.6

Note: ZT=Zero tillage, CT=Conventional tillage, RR=residue removed, RK=residue kept, MS=Maize as sole crop, M+S-W=Maize and soybean intercrop followed by wheat, Ms-W=Maize sole followed by wheat, SEm=Standard Error of Means, LSD=Least Significance Difference, CV=Coefficient of variation

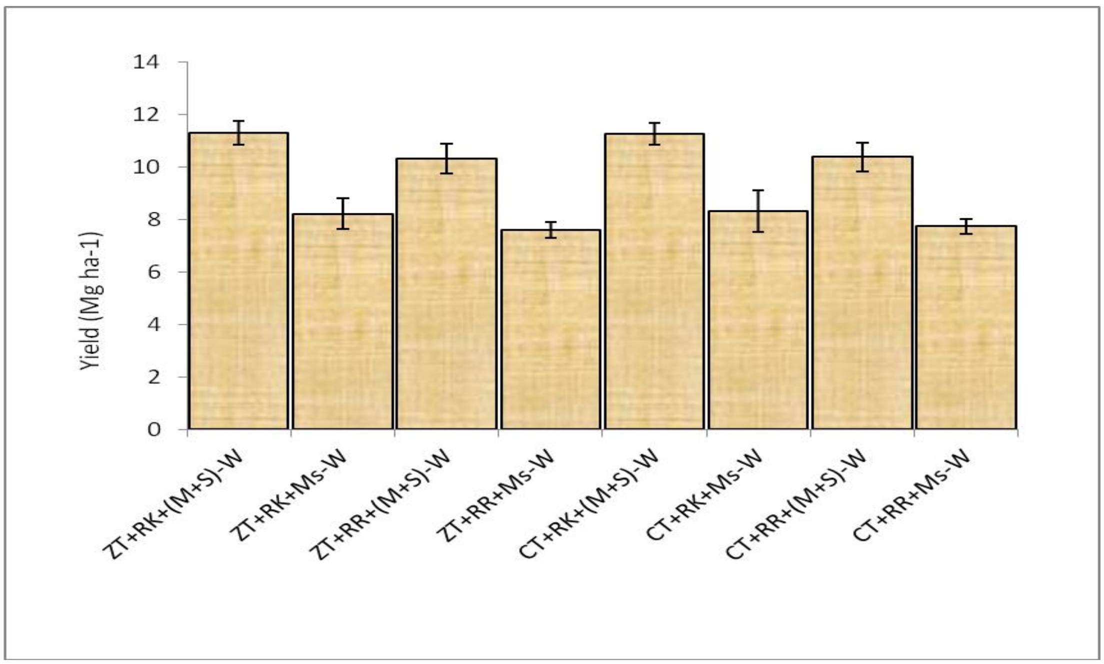

Fig.3 Effect of tillage, residue and crop rotation on system yield under maize-wheat system, Rampur, 2013-2014

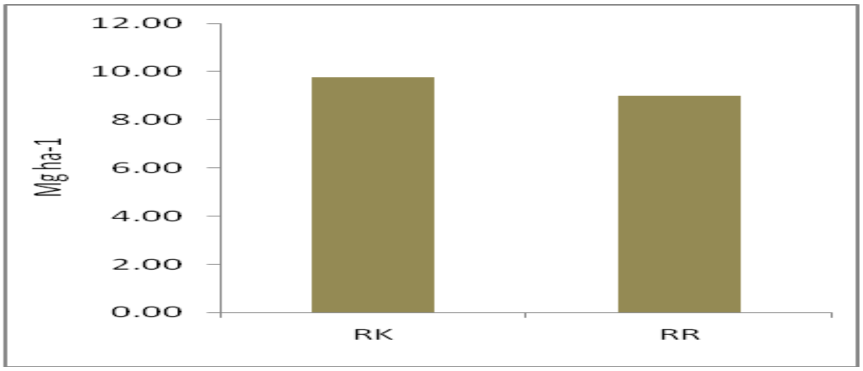

Fig.4 System yield under maize-wheat system as affected by tillage, Rampur, 2013-2014

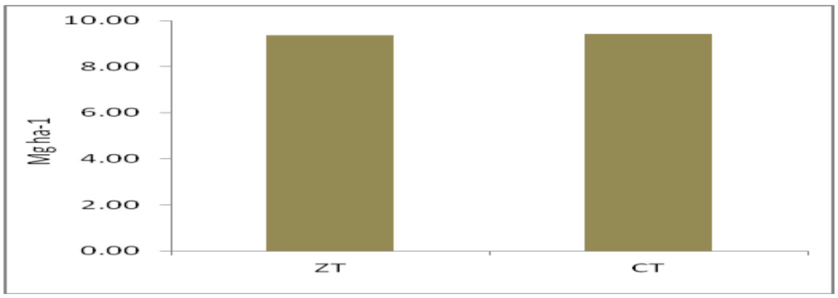

Fig 5 System yield under maize-wheat system as affected by residue, Rampur, 2013-2014

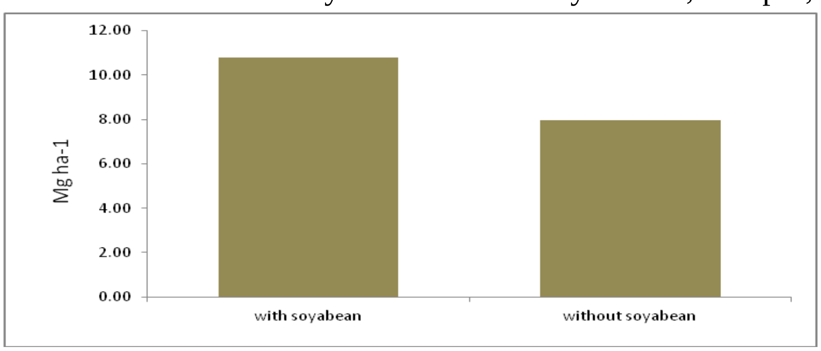

Fig.6 System yield under maize-wheat system as affected by with or without intercropping of soybean, Rampur, 2013-2014

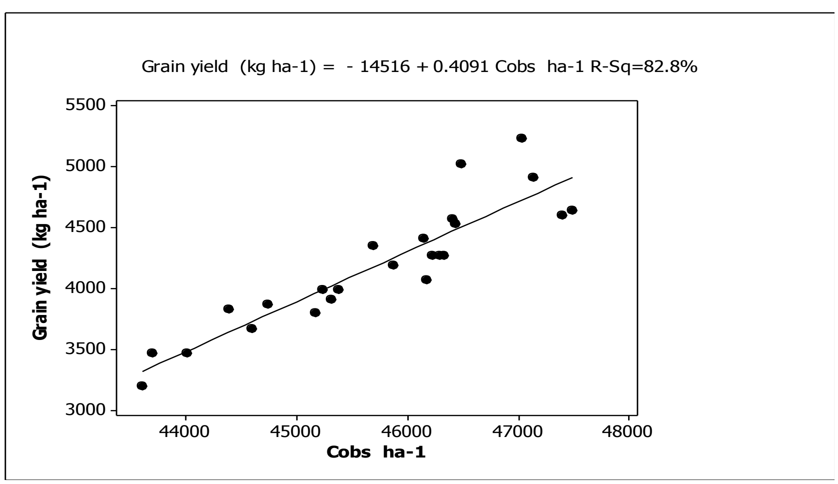

Fig.7 Regression analysis of grain yield in response to number of cobs per hectare

System yield

The grain yields of both the crops of maize as summer and wheat as winter season crop were combined together and ANOVA was prepared according to the treatments. The ANOVA reveled that system yield was affected by the treatment combinations and significantly the highest (11.29 Mg ha^{-1}) of it was recorded in the plot where tillage was omitted, residue was kept and intercropping of maize with soybean during summer and wheat during winter was followed and was at par with conventionally tilled, residue was kept and intercropping of maize with soybean during summer and wheat during winter was followed (11.25 Mg ha^{-1}), conventionally tilled, residue was removed and intercropping of maize with soybean during summer and wheat during winter was followed (10.37 Mg ha^{-1}) and tillage omitted, residue kept and intercropping of maize with soybean during summer and wheat during winter was followed (10.31 Mg ha^{-1}). Obviously, the least system yield was observed in no tilled residue removed and sole crop of maize followed by winter fallow (7.59 Mg ha^{-1}) and was at par with other treatments where winter was kept fallow (Table 6, Fig 2,3,4 and 5).

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References

Allen, H.P. (1981). Direct Drilling Reduced Cultivations. pp. 97-99. Farming Ltd., London.

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

Berry, W.A.J., MalleiI, J.B., Johnston, M.A. (1985). Soil-water conservation as affected by primary tillage practices. S. Afr. J. Plant Soil 2, 21 - 26. MELIS, M. & FARINA, M.P.W.,

Chowdhury, M. K., Rosario, E. L. (1992). Utilization efficiency of applied nitrogen as relayed to yield advantage in maize/mungbean intercropping. Field Crops Research 30:41–51.

Edmeades, G.O., Daynard, T.B. (1979). The relationship between final yield and photosynthesis at flowering in individual maize plants. Canadian Journal of Plant Science 1979; 59 585-601.

Giller, K.E., Wilson, K.J. (1991). Nitrogen fixation in tropical cropping systems. Wallingford, UK: CAB International.

Iqbal, M., Khan, A.G., Hussain, A.U., Islam, K.R. (2013). Tillage and nitrogen fertilization impact on irrigated corn yields, and soil chemical and physical properties under semiarid climate. Journal of Sustainable Watershed Science & Management 1 (3): 90–98.

Jat, M.L., Gupta, R.K., Gopal, R. (2009). Conservation Agriculture in cereal systems of South Asia: effect on crop productivity and carbon-based sustainability index. International Maize and Wheat Improvement Center (CIMMYT), NASC Complex, New Delhi-110012.

Kapusta, G., Krausz, R.F., Matthews, J.L. (1996). Corn yield is equal in conventional, reduced, and no tillage after 20 years. Agron. J. 88, 812±817.

Khurshid, K., Iqbal, M., Arif, M.S., Nawaz, A. (2006). Effect of tillage and mulch on soil physical properties and growth of maize. International Journal of Agriculture and Biology 8(5): 593-596.

Liang, A. Z., Zhang, X. P., Yang, X. M., Mclaughlin, N. B., Shen, Y., Li, W. F. (2009). Estimation of total erosion in cultivated Black soils in northeast China from vertical profiles of soil organic carbon. Eur. J. Soil Sci. 60: 223-229 .

Liang, Y.L., Richards, R.A. (2012). Seedling vigor characteristics among Chinese and Australian wheats. Commun. Soil Sci.Plan. 30:159–165.

MoAD. (2013). Statistical information on Nepalese agriculture 2012/13. Government of Nepal, Ministry of Agriculture and Cooperatives. Agri-Business Promotion and Statistics Division. Singha Durbar, Kathmandu, Nepal.10p.

Olesen, J.E., Hansen, P.K., Berntsen, J., Christensen, S. (2004). Simulation of above-ground suppression of competing species and competition tolerance in winter wheat varieties. Field Crops Res. 89:263–280. doi:10.1016/j.fcr.2004.02.005

Prasad, R. B., Brook, R. M. (2005).Effect of varying maize densities on intercropped maize and soybean in Nepal. Cambridge University Press. Experimental Agriculture 41: 365–382.

Rice, C.W., Smith, M.S., Belvins, R.L. (1986). Soil nitrogen availability after long-term continuous no-tillage and conventional tillage corn production. Soil Sci. Soc. Am. J. 50,

Wright, G. C., Smith, C. J., Nelson, I. B. (1988). Growth and yield of soybean under wet soil culture and conventional furrow irrigation in South-Eastern Australia. Irrigation Science 9: 127-192.