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Effect of Resource Conservation Practices on Productivity of Maize Intercropped with Soybean under Maize + Soybean – Wheat Cropping System and Soil Microbial Population

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A B S T R A C T

An investigation entitled "Effect of resource conservation practices on productivity of maize intercropped with soybean under Maize + Soybean – wheat cropping system and soil microbial population" was conducted at the Research Farm, Main Campus, Chatha of SKUAST–Jammu during the year 2012-13 and 2013-14. The experiment was laid out in split- plot design with two crop establishment methods (Minimum / Zero tillage and conventional tillage) and three cropping systems (Rice-Wheat, Rice-Marigold-French bean and Maize + soyabean -Wheat) and two fertilizer rates (Rec. Dose of Fertilizer and 75% RDF + 25%N through FYM) with and without mulching in sub-plots under clay loam soil having alkaline in reaction (pH-8.1), medium in soil organic carbon, available P & K and low in available N. It has been observed that higher plant height, leaf area index, dry matter production (g/m^2), number of plants/sqm, number of rows per cob, number of pods per plant, number of grains per cob and number of grains per pod grain yield, stover yield and harvest index was found under conventional tillage as compare to minimum tillage with mulching @ 5ton paddy straw in conjugation with 75% RDF + 25% N through FYM. Similarly higher cost of cultivation, gross return, net return, BC ratio was registered under conventional tillage as compare to minimum tillage with mulching @ 5ton paddy straw in conjugation with 75% RDF + 25% N through FYM. Significantly, higher microbial population was observed under minimum tillage, maize + soybean - wheat cropping system, and application of 75% RDF + 25% N through FYM.

Introduction

Maize is the third most important cereal crop of world and India after wheat and rice. Maize has diversified uses as food for human, feed for livestock and raw material in industries. Out of the total production 45% is consumed as staple food in various forms. Maize alone accounts 30% of total global grain production and the crop is cultivated on 161.11 m ha of land worldwide producing 826.22 mt with an average yield of 51.28 q/ha (Digest of Statistics, 2012). In India maize is grown on 8.49 million ha with production and productivity of 21.49 million ton and 2.51ton per hectare. It is miracle crop because of its

high proteinal value and is also known as 'queen of cereals'. In J&K state maize has special significance because it forms the staple diet of majority of people. The total area under maize crop in the state is about 308.22 thousand hectare, having a production and productivity of 4098 thousand quintal and productivity 18.72 q/ha (Digest of Statistics, 2012) which is low as compared to average national productivity. Maize being C_4 plant has tremendous yield potential and responds well to applied inputs and is grown under both the irrigated and rain fed ecosystem and hence is having wider adaptability with respect to season and altitude and can mitigate the effect of climate change as C_4 plants have higher temperature optimum for photosynthesis and growth than C_3 plants and thus are better adapted to warmer climate (Kim *et al.,* 2007).

Intercropping of maize with legume crop is an efficient strategy which not only acts as insurance but also have many benefits such as stable yield, better use of resources, weed control, pest and disease reductions, increased available nitrogen and reduce the need of synthetic fertilizers and in conjugation with conservation tillage practices reduce soil erosion. Yield of cereals following legumes are reported to be 30-35% higher than those following a cereal cropping sequence. Besides N fixation, legumes also help in solublisation of phosphorous, increase in soil microbial activity, organic matter restoration and improvement physical health of soil (Acharya and Bandyopadhyay, 2002). Soyabean known as golden bean of 21th century has the ability to fix atmospheric nitrogen in the soil in association with Bradyrhizobium rhizobia and can fix about 61-337 kg N/ha (Salvagiotti *et al.,* 2008) which reduces the 25% N requirement for the crop and saves about 5% cost of required fertilizers (Mahindra, 2011).

The total area and production of soybean in India is 104 lakh tonnes and 102 lakh tonnes, respectively. In the J&K state the area under soybean production is almost negligible.

However, modern agricultural production technology aims at maximization of productivity per unit area per unit time with intensive use of synthetic fertilizers, pesticides, fossil fuel based energy which are leading to degradation of natural resource i.e. Soil, water, environment and biodiversity. Hence, present investigation was conducted to study the "Effect of resource conservation practices on productivity of maize intercropped with soybean under Maize + Soybean – wheat cropping system and soil microbial population."

Materials and Methods

The field experiment was conducted during *Rabi, Kharif* and *Zaid* seasons of 2012-13 and 2013-14 at the Research Farm, FSR, Centre, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Main Campus Chatha, Jammu located at an latitude of 32^0-40*'* N and longitude of 74^0-58*'* E with an altitude of 332 m above mean sea level. The climate of Jammu is Sub-tropical (Low altitude sub-tropical zone of Jammu) with hot and humid rainy season, hot dry summer and warm autumn and cool winter. The maximum temperature during summer rises to about 42^{o}C and minimum temperature during winter fall to 3^{o}C. Average rain fall of the study area is 1150 mm, major portion of which is received during the months of July to September. The experiment was laid out in split- plot design with two crop establishment methods (Minimum/Zero tillage and conventional tillage) and three cropping systems (Rice-Wheat, Rice-Marigold-French bean and Maize + soybean -Wheat) in main plot and two fertilizer rates (Rec. Dose of Fertilizer and 75% RDF + 25%N through FYM) with and without mulching in sub-plots making 24 treatment combinations with three

replications. In this paper more emphasis has been given to maize + soyabean - wheat cropping system among three different cropping systems. The soil of the experimental site was clay loam in texture having alkaline in reaction (pH-8.1), medium in soil organic carbon, available P & K and low in available N.

During both the years rice was sown directly with zero till drill at seed rate of 25kg/ha under minimum tillage practice during the month of June and simultaneously rice was sown through dry seeding @ of 40 kg/ha in well pulverized nursery bed for transplanted rice (conventional methods of crop establishment) and 25 days age old seedlings were transplanted in the field at experimentation site having plot size of 12mx5m. The plots were prepared in such a way in both seasons to avoid any transportation of soil from one plot to another. For keeping the weed flora below the thresh hold value pendimethalin @ 1kg/ha as pre-emergence was applied just after the sowing of direct seeded rice followed by bispyribac sodium @.025kg/ha, as post-emergence after 25 days of sowing followed by one hand weeding at 60 DAS. In conventional method of crop establishment, field was first ploughed by the tractor driven tiller, then the soil was puddled with puddler and the transplanting of single seedling per hill was done. Machette granular 5% a.i @30 kg /ha was applied just after transplanting of rice. Application of 25% N through FYM (as per treatment) was given 15 days before sowing/transplanting the crop and half dose of Nitrogen (50 Kg/ha) as basal and full dose of P&K (30kg/ha and 20 kg/ha) was applied at the time of sowing. Short duration variety IET-1410 (120 days maturity period from seed to seed) was used at a spacing of 20 × 15 cm in the plots where the crop established through transplanting method, whereas the crop sown under direct seeding through zero tillage seed drill did not observe any specific plant to plant distance. However, plant population was maintained by applying seed rate 25kg/ha but the line to line distance of 20 cm was maintained. Water management was done by irrigating the field as the hair like cracks on the top soil crust appeared in direct seeded rice, whereas the irrigation was applied through flooded method. Harvesting was done manually with the help of sickle from net plot area (10m x 4m) and manually threshed grain and straw yield was recorded as per treatment. Hybrid maize crop (variety- double Monsanto) was also raised during *kharif* season i.e., third week of June during both the years. The field was prepared with tiller followed by rotavator under conventional method of sowing and seeds were directly sown with line marker under both the methods of sowing (minimum/zero tillage and conventional tillage) using seed rate of 20kg/ha having spacing of 60 x 20 cm. whereas, Soybean crop was taken as inter crop, an additive series (1:1) with a seed rate of 20kg/ha. Half dose of N and full dose of P&K was applied as basal dose at the time of sowing and rest dose in splits at knee-high and tasselling stage. Weeding was done manually with the help of *khurpi* at 20 and 40 DAS and earthing was done manually at knee high stage 25 DAS. Crop was harvested manually from net plot area (9.60m x 4m) and threshed grain and straw yield was recorded plot-wise.

During *rabi* season, the wheat variety *PBW 557* was sown in the month of November using seed drill @ 100 kg seed/ha for crop established under conventional practice whereas under minimum tillage, zero till drill was used with same seed rate. and marigold (*Pusa Narangi*) crop was raised in nursery in September @ 1 kg seed/ha and later transplanted in the month of October at the experimental site at distance of 50X40cm. Weedicide clodinofop propogyl @ 0.06kg/ha was applied 30 DAS followed by 2,4-D @

0.5kg/ha at 35 DAS. Mulching with rice straw @ 5ton/ha was spread manually between the rows of wheat crop which covered 60-90 % area between rows. Harvesting was done manually from net plot area (10m X 4m) and threshed by using tractor- operated thresher and yield was recorded as per treatment. In case of marigold crop field, the nipping of buds was done manually after25 DAT, whereas the mulching at 10 DAT with rice straw spread in between the rows in treatments where mulching as treatment was done. For effective weed control, mechanical weeding with *khurpi* was done at 20 DAT. Harvesting, by plucking loose flowers manually and weight of flowers per net plot area (10mX4m) was recorded as per treatment. In summer season, French bean crop (variety-Contender) with a seed rate of 80kg/ha at spacing of 60X10 cm was sown manually with line marker under minimum tillage practice and conventional method of sowing. The harvesting was done by picking fresh green pods from net plot area (9.60m X 4m) in 5 pickings. The total productivity of the cropping system was expressed as rice equivalent yield (REY). For production efficiency, land use efficiency, system profitability and economics analysis (cost of cultivation and net return) for each treatments was also calculated using standard procedure. Statistical analysis was carried out using standard methodology of split plot design. The rice equivalent yield was calculated by using the following formula:

$$REY = \frac{\Sigma. Yi \times Pi}{P(p)}$$

Where,

REY denotes rice equivalent yield
Yi = yield of different crops
Pi = price of respective crops
P (p) = price of paddy

Enumeration of fungi, bacteria and actinomycetes were done by the serial dilution-agar plating method or viable plate count method. The number of colonies appearing on dilution plates are counted, averaged and multiplied by the dilution factor to find the number of cells/spores per gram (or millimeter) of the sample:

No. of cells/ml or g = No. of colonies (average of 3 replications) x Dilution factor

Dilution factor = Reciprocal of the dilution (e.g. $10^{-6} = 10^{6}$)

Results and Discussion

Growth, Yield attributes of maize + soyabean

Between crop establishment methods, conventional method of sowing of maize + soybean crop produced taller plants, higher leaf area index, dry matter production (g/m^2), number of plants/sqm, number of rows per cob, number of pods per plot, number of grains per cob and number of grains per pod as compare to minimum tillage. This increase in growth parameters might be due to better pulverization of soil which helped in the better aeration, nutrient availability, better crop higher water and nutrient use efficiency and less weed crop competition over zero tillage. These results were in accordance with Painyali *et al.,* (2013) and Ramesh *et al.,* (2014) Mulching with paddy straw @ 5 ton/ha to *rabi* crop recorded higher value of taller plants, higher leaf area index, dry matter production (g/m^2), number of plants/sqm, number of rows per cob, number of pods per plot, number of grains per cob and number of grains per pod dry matter accumulation (g/m^2) and leaf area index. Mulching has favourable effect of soil physical, chemical and biological properties such as soil pH, organic carbon and water holding capacity of soil (Singh *et al.,* 2005).

Application of 75% RDF coupled with 25% N through FYM resulted in higher growth and yield parameters over 100 % RDF. Integration of inorganic fertilizer with organic source of nutrients corrected the deficiency of micro and macro nutrients to attain healthy crop growth.

Yield of maize + soybean

Under crop establishment methods, conventional tillage recorded higher grain yield and stover yield in comparison to minimum tillage. Sharma *et al.,* (2009) also reported that significantly higher grain yield of maize was recorded in conventional tillage. Saha *et al.,* (2010) reported similar results. Mulching with rice straw @5 ton/ha to *rabi* crops and application of 75% RDF + 25% N through FYM resulted higher values of grain yield and stover yield of maize and soybean crop as compared to no mulching treatments. Mulching enhances the nutrients availability on decomposition and microbial activity which might be responsible for such increase under maize crop. Badiyala and Chopra (2011), Tetarwal *et al.,* (2011) and Joshi *et al.,* (2013) also confirmed these findings. Harvest index which is the better indicator of partitioning of photosynthates ranged between 34.28 to 34.63% in case of maize crop and 33.05 to 33.16% shows a very little increase in harvest index (Table 1).

Rice Equivalent Yield (REY q/ha)

Under crop establishment methods, conventional tillage recorded significantly higher rice equivalent yield of 223.39 q /ha and 198.48q/ha in first and second year, respectively than the minimum tillage which works out to be 14.77 per cent higher. Lower economic yields under minimum tillage which may be due to poor crop establishment due to higher microbial resistance to soil and crop weed competition (Brar *et al.,* 2011). Under various cropping system treatments, rice-marigold-French bean produced significantly higher REY of 223.39q/ha and 198.48 q/ha during first and second year with average of 210.94 q/ha than followed by maize + soyabean - wheat (101.87 q/ha and 93.89 q/ha, with average of 87.88 q/ha) over existing rice-wheat cropping system, which produced REY of 83.39 q/ha and 75.09 q/ha in first and second year, respectively. Kachroo *et al.,* (2012) reported that rice-garlic-cowpea recorded the highest average REY followed by rice-potato-onion and rice-marigold-French bean than rice-wheat system. Shivay *et al.,* (2001) also reported that involving legume as intercrop in maize crop increased the maize equivalent yield. Rice equivalent yield (REY), during both the years, under cover with rice mulch (more than 66% land cover) during *rabi* season produced significantly higher values of REY (140.06q/ha and 126.49 q/ha). Desai *et al.,* (2014) reported that significantly higher paddy equivalent yield was recorded in mulching over no mulch. However, between the fertilizer applications, 75% recommended dose of fertilizer coupled with 25% N through FYM to each crop in a cycle during both the years of experimentation resulted significantly higher REY of 138.55 and 124.8 q/ha, over 100% recommended dose of fertilizer application owing to higher crop yields (Table 3).

Economics

Under crop establishment methods, minimum tillage recorded lower cost of cultivation, gross return, net return and B: C ratio. The higher gross returns, net returns and B: C ratio under conventional tillage practices was probably due to better crop yield under conventional tillage. Even the cost of cultivation was higher in conventional tillage but higher gross returns compensated the high cost of cultivation and resulted in higher net returns and B: C ratio. These results are similar with the findings of Painyuli *et al.,* (2013).

Table.1 Growth parameters and yield attributes of maize + soybean as influenced by crop establishment methods, cropping systems, mulching and fertilizer rates (mean of two years)

Treatment	Plant height (cm)		Leaf area index		Dry matter (g/m^2)		No of plants/m^2		No. of rows/ cob & No. of pods/plant		No. of grains/ cob & No. of grains/pod	
	Maize	Soyabean	Maize	Soyabean	Maize	Soyabean	Maize	Soyabean	Maize	Soyabean	Maize	Soyabean
Crop Establishment Methods												
Minimum Tillage	165.17	80.56	4.03	2.14	896.86	445.62	7.19	20	14.30	18.72	20.37	2.46
Conventional Tillage	173.73	86.02	4.19	2.36	984.5	490.12	8.25	21	16.10	21.40	22.22	2.87
Cropping systems												
Rice-Wheat	-	-	-	-	-	-	-	-	-		-	
Rice-Marigold-Frenchbean	-	-	-	-	-	-	-	-	-		-	
Maize+soybean-Wheat	168.95	83.29	4.11	2.25	986.08	467.87	7.50	20.5	15	20.06	21.45	2.63
Mulching												
No Mulch	168.24	82.19	4.09	2.22	971	460.5	7.70	19.50	15.15	19.63	20.46	2.56
Mulch with rice straw	170.16	84.4	4.13	2.27	1006.74	475	7.70	20.50	15.95	20.50	22.48	2.78
Fertilizer rates												
100% RDF	169.41	82.4	4.05	1.97	908.4	355.87	7.40	20.0	14.10	19.14	21.14	2.48
75%RDF+25% N through FYM	172.94	84.19	4.16	2.28	967	480	7.54	20.8	14.95	20.98	21.80	2.29

Table.2 Growth parameters of maize+soybean as influenced by crop establishment methods, cropping systems, mulching and fertilizer rates (mean of two years)

Treatment	Grain yield(kg//ha)		Stover yield (kg//ha)		Harvest index (%)		Gross return	Cost of cultivation	Net return	B:C Ratio
	Maize	Soyabean	Maize	Soyabean	Maize	Soyabean				
Crop Establishment Methods										
Minimum Tillage	3247	632	6245	1284	34.28	33.06	80263	32265	43998	1.22
Conventional Tillage	3636	739	6895	1493	34.63	33.12	910405	37765	53276	1.42
Cropping systems										
Rice-Wheat	-	-	-	-	-	-				
Rice-Marigold-Frenchbean	-	-	-	-	-	-				
Maize+soybean-Wheat	3442	686	6570	1388	34.45	33.09	85652	37015	48637	1.32
Mulching										
No Mulch	3357	625	6401	1263	34.49	33.12	81734	37015	44719	1.22
Mulch with rice straw	3526	747	6738	1514	34.42	33.05	89565	37015	52550	
Fertilizer rates										
100% RDF	3378	657	6444	1335	34.46	33.01	83367	33015	50352	1.54
75%RDF+25% N through FYM	3506	716	6695	1443	34.45	33.16	83937	41015	42922	1.06

Table.3 Rice equivalent yield as influenced by crop establishment methods, cropping systems, mulching and fertilizer rates

Treatment	REY (kg/ha)		
	2012-13	2013-14	Mean
Crop Establishment Methods			
Minimum Tillage	12848	11581	12214
Conventional Tillage	14395	12916	1366
SEM ±	**37.3**	**61.9**	**49.6**
***LSD* (P=0.05)**	**113.3**	**188**	**150.65**
Cropping System			
Rice-Wheat	8339	7509	7924
Rice-Marigold-Frenchbean	22339	19848	21094
Maize + Soybean –Wheat	10187	9389	8788
SEM ±	**45.7**	**75.9**	**60.8**
***LSD* (P=0.05)**	**138.7**	**230**	**184.35**
Mulching			
No Mulch	13237	11848	12542
Mulch with rice straw	14006	12649	13327
SEM ±	**37.5**	**33.1**	**35.3**
***LSD* (P=0.05)**	**106.8**	**94**	**100.4**
Fertilizer Rates			
100% RDF	13386	12016	12702
75%RDF+25% N through FYM	13855	12481	13168
SEM ±	**37.5**	**33.1**	**35.3**
***LSD* (P=0.05)**	**106.8**	**94**	**100**

Table.4 Microbial count of crop establishment methods, cropping systems, mulching and fertilizer rates (mean of two years)

Treatment	Bacteria (x 10^6 CFU/g)	Fungi (x 10^3 CFU/g)0^3)	Actinomycytes (x 10^4 CFU/g)
Crop Establishment Methods			
Minimum Tillage	15.78	21.44	20.11
Conventional Tillage	14.04	17.80	17.91
SEM ±	**0.35**	**0.65**	**0.50**
***LSD* (P=0.05)**	**1.05**	**2.05**	**1.5**
Cropping System			
Rice-Wheat	13.35	18.32	17.89
Rice-Marigold-Frenchbean	14.83	20.27	19.90
Maize + Soybean –Wheat	16.15	20.25	19.25
SEM ±	**0.45**	**0.85**	**0.6**
***LSD* (P=0.05)**	**1.3**	**2.50**	**1.85**
Mulching			
No Mulch	14.25	19.08	18.69
Mulch with rice straw	15.22	20.15	19.28
SEM ±	**0.45**	**0.55**	**0**
***LSD* (P=0.05)**	**1.25**	**1.55**	**0.45**
Fertilizer Rates			
100% RDF	13.76	17.82	17.83
75%RDF+25% N through FYM	15.77	21.41	20.99
SEM ±	**0.45**	**0.55**	**0.45**
***LSD* (P=0.05)**	**1.25**	**1.55**	**1.35**

Mulching with paddy straw @ 5 ton/ha to *rabi* crop registered higher gross returns, net returns and B: C ratio in comparison to no mulch treatments. Under mulched plots, higher grain and stover yield was achieved and resulted in higher net return and B: C ratio. Application of 75% RDF and 25% N through FYM recorded higher cost of cultivation and higher gross returns but lower net returns and B: C ratio over 100% RDF. FYM cost increased the cost of cultivation of maize crop which lowered the B: C ratio and maximise the B: C ratio under 100% RDF treatments. Badiyala and Chopra (2011) reported that higher B: C ratio (1:1.5) was recorded with application of recommended NPK to both crops (maize + linseed). Tetarwal *et al.*, (2011) reported that 150% RDF fetched higher net returns and B: C ratio in rainfed maize (Table 2).

Microbial count

The microbial population in terms of bacteria, fungi and actinomycetes were presented in Table 4. In general, it has been observed that the microbial population showed significant difference under different treatments and the higher microbial population was observed at the end of each cropping cycle of the year

Bacteria

Under crop establishment methods minimum tillage recorded significantly higher population of bacteria ($15.78x10^6$cfu/g) as compared to conventional tillage (14.4×10^6 cfu/g). Similarly, maize + soybean-wheat cropping system observed significantly higher number of bacterial count ($16.15x10^6$ cfu/g) than rice-marigold-French bean ($14.83x10^6$ cfu/g) and rice-wheat ($13.35x10^6$ cfu/g) cropping system. Bacterial count under cover with rice straw @5ton/ha was found non-significant. Application of 75% RDF+25%N through FYM observed significantly higher population of bacteria (15.77×10^6 cfu/g) over 100 % RDF ($13.76x10^6$ cfu/g).

Fungi

Under crop establishment methods, the population of fungi was found significantly higher under minimum tillage (21.44×10^3 cfu/g) as compared to conventional tillage (17.80×10^3 cfu/gm) which was 20.44 per cent higher population than conventional tillage. However, under various cropping system treatments, maize + soybean – wheat cropping system recorded maximum fungi population which was at par with rice-marigold-French bean and significantly different from rice-wheat cropping system. The per cent increase under maize + soybean – wheat cropping system was 10 per cent over traditional rice-wheat cropping system during. Mulching had also non-significant effect on fungi population, whereas 100% RDF+25 % N through FYM registered significantly higher value of fungi population which was 20.0 as compared to 100% RDF.

Actinomycetes

Under crop establishment methods, minimum tillage registered significantly higher population of actinomycetes (20.11×10^4 cfu/g) which was 12.62 per cent higher over conventional tillage (17.91×10^4 cfu/g). Similarly, under different cropping system treatments, rice-marigold-frenchbean which was at par with maize + soybean-wheat cropping system registered significantly higher value of actinomycetes population over rice-wheat cropping system. Similarly, mulching had no effect on population of actinomycetes. Between fertilizers application, 75% RDF + 25% N through FYM to each crop in a cycle resulted significantly higher actinomycetes population (20.99×10^4 cfu/g) over 100% RDF application.

Based on two years of experimentation, it can be concluded that higher values of yield attributes, yield and harvesting index were recorded in conventional tillage with mulching @ 5 ton/ha paddy straw in combination with application of 75% RDF + 25%N through FYM. Moreover significantly, higher microbial population was observed under minimum tillage, maize + soybean - wheat cropping system, and application of 75% RDF + 25% N through FYM. whereas, in case of system REY of different cropping systems, application of paddy straw as mulch @ 5 ton/ha during Rabi season with INM under conventional method of sowing to Rice-Marigold-French bean has yielded maximum REY of 210.93 q/ha.

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