I J T A
© Serials Publications
National Academy of Agricultural Science (NAAS) Rating : 3.03

Influence of Tillage and Land Configuration on the Growth, Productivity and Economics of Cotton - Maize Cropping Systems

P. Puvila* and K. Siddeswaran*

ABSTRACT: *A field experiment with different tillage practices and land configurations in cotton - maize cropping systems was conducted at TNAU, Coimbatore during 2011-12 and 2012-13. Totally there were 8 treatments which were replicated thrice in a randomized block design. The treatments consisted of three tillage practices viz., conventional tillage, reduced tillage and zero tillage and three types of land configurations viz., flat bed and furrow irrigated raised bed (FIRB) which were compared with the existing practice of ridges and furrows. The result of two cropping cycles revealed that the growth parameters, yield attributes and seed cotton yield of cotton were higher in the reduced tillage to both cotton and maize and planting on FIRB which was on par with conventional tillage to both cotton and maize and planting on ridges and furrows (existing practice as check), conventional tillage to both cotton and maize and planting on FIRB, reduced tillage to both cotton and maize and planting on FIRB and reduced tillage once to cotton alone and planting on FIRB. In maize, better growth, improved yield parameters and higher yield were recorded in the reduced tillage to both cotton and maize and planting on FIRB. The lowest yield of cotton and maize was recorded in the zero tillage to both the crops and planting on flat bed. In the cotton-maize system, cotton equivalent yield (CEY) was almost similar in reduced tillage to both cotton and maize and planting on FIRB (4784 kg/ha), existing practice of conventional tillage to both cotton and maize and planting in ridges and furrows (4755 kg/ha) and conventional tillage to cotton alone and planting both cotton and maize on the FIRB (4750 kg/ha). With regards to economics for the cotton- maize cropping system as a whole, conventional tillage to cotton alone and planting both cotton and maize on the FIRB recorded the highest net return of Rs.1,31,501/ha/year with a B-C ratio of 2.21 followed by reduced tillage to both cotton and maize and planting on FIRB (Rs.1,31,361/ha/year) and existing practice of conventional tillage to both cotton and maize and planting in ridges and furrows (Rs.1,26,197/ha/year).*

Key words: *FIRB, Flat bed, Conventional tillage, Minimum tillage, Zero tillage*

Cotton *(Gossypium hirsutum* L.), the king of fibre crops, is being the most important commercial crop of India (117.73 lakh ha with a production of 365.1 lakh bales of lint and productivity of 496.39 kg ha^{-1} in 2012-13) contributes to around 80% of the raw material to the textile industry and provides employment to nearly 60 million people. Maize (*Zea mays* L.) is the third most important cereal crop next to rice and wheat in India and also a predominant cereal in global agricultural economy. It is used both as food for human and feed for livestock especially in poultry industry. It has got immense yield potential and is therefore called as "miracle crop" and also "queen of cereals". Cotton-maize sequence is one of the most remunerative systems with high productivity levels. Both cotton and maize, with different rooting pattern responds to tillage differently. According to several reports conventional agriculture mainly characterized by intensive tillage has contributed to soil degradation through loss of organic matter, soil erosion and compaction. This has led to negative effects on soil, water and air qualities, global climate, wildlife and biodiversity. Poor soil tilth lowers the infiltration and percolation rates, nutrient movement and free air transport within the soil profile and the contribution of soil fertility to crop growth is hampered. Conservation agriculture has wide range of benefits including improvement in soil fertility, reduction in soil erosion, carbon accumulation, savings in time and energy (fuel), and increase in biodiversity (Reicosky and Saxton, 2007). In this context, conservation agriculture practices which include no-tillage, reduced tillage/ minimum tillage are being focused in recent times. The minimum tillage not only helps

* Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore - 641003, *E-mail: earthpuvi@gmail.com*

to suppress germination and growth of weeds but also increase water use efficiency and provides saving of labour and fuel. The use of herbicides combined with minimum tillage will helps to reduce the cost of cultivation and thereby resulting in increased returns. Adoption of appropriate land configuration to crops results in better crop and water productivity, besides good weed management. In this context an experiment was conducted during 2011-2013 to study the impact of tillage and land configuration on the productivity and economics of the cotton - maize cropping systems.

MATERIALS AND METHODS

Field experiments were conducted during winter and summer seasons of 2011-12 and 2012-13 at Tamil Nadu Agricultural University, Coimbatore to study the influence of tillage and land configuration on the growth, productivity and economics of cotton - maize cropping systems. The experiment with cotton - maize (NK 6240) cropping system was laid out in a randomized block design with eight treatments replicated thrice. The treatment combinations were, T_1: Conventional tillage to both cotton and maize and planting on flat bed, T_2: Conventional tillage to both cotton and maize and planting on furrow irrigated raised bed (FIRB), T_3: Conventional tillage once to cotton alone and planting on FIRB, T_4: Reduced tillage to both cotton and maize and planting on flat bed, T_5: Reduced tillage to both cotton and maize and planting on FIRB, T_6: Reduced tillage once to cotton alone and planting on FIRB, T_7: Zero tillage and planting on flat bed and T_8: Conventional tillage to both cotton and maize and planting on ridges and furrows (existing practice as check). The soil of the experimental site was sandy loam in texture. The soil was alkaline and has low to medium soluble salt content and low in available N (224 kg/ha), medium in available P (15 kg/ha) and high in available K (450 kg/ha). During the cropping period, the maximum and minimum temperature ranged from 26 °C to 36 °C and 15.4 °C to 26.0 °C during 2011-12 and 28.0 °C to 36.7 °C, 18.4 °C to 25.3 °C during the 2012-13 respectively. The total rainfall received during the cropping period in 2011-12 and 2012-13 were 734.0 mm and 395.7 mm in 34 and 23 rainy days, respectively. Cotton hybrid (Bunny Bt.) with duration of about 160-170 days was raised during winter irrigated season (August to February) and maize hybrid (NK 6240) of 100-105 days duration was grown during March- June.

For cotton crop, after marking plots, in the conventional method of tillage and ridges and furrows, two ploughings with five tyne duck foot cultivator and then two ploughing with 11 tyne cultivator followed by one rotavator ploughing were given. In the reduced tillage system, one ploughing with five tyne duck foot cultivator, one 11 tyne cultivator followed by one rotavator were provided. Totally five ploughings were given in the conventional tillage and three ploughings in the reduced tillage system. In zero tillage, there was no mechanical disturbance to the soil. Only herbicides were used to control weeds in the zero tillage plots and treatments received tillage (either conventional tillage or reduced tillage) only once i.e., cotton alone. After ploughing operations, individual plots were thrown into flatbeds, FIRB and ridges and furrows as per the treatment structure. In FIRB, raised beds of 105 cm to a height of 15 cm were formed with furrow width of 30 cm. Flat beds were formed with a bullock drawn bund former to the required size and beds were levelled manually. By engaging tractor drawn ridge plough, ridges were formed 90 cm apart. Delinted Bt bunny seeds with a seed rate of 1.5 kg ha^{-1} were dibbled at the rate of one seed per hill with a spacing of 90 x 60 cm. Refuge seeds were planted along the border plots (outs) all around the experimental field. Recommended fertilizer dose of 150: 75: 75 kg NPK ha^{-1} was applied for hybrid cotton (Bt bunny). First irrigation was given immediately after sowing followed by life saving irrigation on third day. Based on the soil moisture condition and rainfall, subsequent irrigations were scheduled at 10-15 days interval.

After the harvest of the first crop cotton, without disturbing the layout, the field was prepared as per treatment schedule and the second crop maize was raised. As done for cotton, in conventional method of tillage totally five ploughings, two five tyne cultivator, two 11 tyne cultivator followed by one ratavator ploughing were given. Three ploughings (one five tyne duck foot cultivator, one 11 tyne cultivators followed by one ratavator) were adopted in reduced tillage system. In T_3 and T_6, where tillage was restricted to only once in the sequence i.e., cotton alone and in zero tillage plots, there was no mechanical disturbance to the soil. The weeds present in the plots were controlled with total herbicide Glyphosate after the harvest of cotton. Before sowing maize, weeds present, if any, were removed and the flat beds/ FIRB were rectified manually. Maize hybrid NK 6240 with seed rate of 15 kg ha^{-1} was adopted and one seed per hill was dibbled at spacing of 60 cm between rows and 25 cm within the row. The recommended fertilizer dose of 150: 75: 75 kg NPK

ha^{-1} was applied to maize (NK 6240). All the recommended package of practices were adopted to both cotton and maize as per the Crop production guide of Tamil Nadu.

The important bio metric observations on growth and yield parameters were recorded. The seed cotton (kapas) from the fully opened bolls was harvested from the net plot area. The kapas obtained from each harvest was weighed and the yield of all pickings were added and expressed as kg ha^{-1}. The cotton stalk in the net plot area were cut, sun dried and the weight was recorded in kg ha^{-1}. In the case of maize, the cobs from the net plot area were harvested, sheaths removed and the grains were shelled. The kernel weight of each treatment was recorded at 14 per cent moisture and expressed in kg ha^{-1}. Stover yield was recorded after sun drying for three days in the field and expressed in kg ha^{-1}. The data collected were analysed statistically and results presented.

RESULTS AND DISCUSSION

Growth Parameters, Yield Parameters and Yield of Cotton

The growth parameters like leaf area index (LAI) and dry matter production (DMP) in cotton were significantly influenced by the different tillage and land configuration methods. The cotton LAI at 90 DAS was significantly higher in the conventional tillage to both cotton and maize and planting on furrow irrigated raised bed during 2011-12 and 2012-13 (Table 1). The lower LAI was recorded in the zero tillage with flat planting. Higher DMP (5678 kg/ha) at harvest was realized in reduced tillage to both cotton and maize and planting on FIRB during 2011-12, whereas in 2012-13 higher DMP at harvest (4813 kg/ha) was recorded in conventional tillage to both cotton and maize and planting on ridges and furrows. The minimum DMP was obtained when cotton was cultivated under zero tillage with flat surface planting method of land configuration during both the years of study.

The cotton yield parameters like number of sympodial branches, number of bolls per plant were significantly influenced by the tillage and land configuration methods whereas boll weight was not significantly influenced by the different treatment combinations. During 2011-12, higher symbodial branches (17.41) was recorded in reduced tillage to both cotton and maize and planting on FIRB which was on par with conventional tillage once to cotton alone and planting on FIRB (17.21) and in 2012-13, conventional tillage once to cotton alone and planting on FIRB recorded higher symbodial branches (16.40) which was on par with reduced tillage to both cotton and maize and planting on FIRB (15.92. Conventional tillage once to cotton alone and planting on FIRB recorded higher bolls per plant (48.20) and which was followed by conventional tillage to both cotton and maize and planting on ridges and furrows (46.53) in 2011-12. Reduced tillage to both cotton and maize and planting on FIRB registered higher bolls per plant during 2012-13, which was followed by the conventional tillage to both cotton and maize and planting on ridges and furrows (Table 1). The cotton yield parameters were minimum when crops were planted on flat surface coupled with zero tillage or conventional tillage.

Seed cotton (kapas) and stalk yield were significantly influenced by tillage practices with different land configuration during 2011-12 and 2012-13. Reduced tillage to both cotton and maize and planting on FIRB registered higher cotton yield of 2887 kg/ha which was statistically on par with conventional tillage to both cotton and maize and planting on ridges and furrows (2802 kg/ha), conventional tillage once to cotton alone and planting on FIRB (2746 kg/ha) and conventional tillage to both cotton and maize and planting on flat bed (2698 kg/ha) during the first year of experimentation (Table 3). The same trend was followed in the second year also. The higher plant density, growth parameters and yield parameters in the above treatments leads to the higher cotton kapas yield. Similar results were reported by Abaye *et al*. (1995) and Aydin Unay *et al*. (2005). The cotton kapas yield was lesser when zero tillage or conventional tillage practices adopted with flat surface planting.

Growth Parameters, Yield Parameters and Yield of Maize

Tillage and land configuration had significantly influenced the growth, yield attributes and yield in maize. The LAI at 60 DAS was significantly higher in the conventional tillage once to cotton alone and planting on FIRB during 2011-12 and in 2012-13, conventional tillage to both cotton and maize and planting on ridges and furrows registered higher LAI (Table 2). Higher DMP of maize at harvest was obtained in conventional tillage once to cotton alone and planting on FIRB during 2011-12 (15229 kg/ha) and 2012-13 (11746 kg/ha). Meenakshi Gupta *et al.* (2011) observed that DMP increased with advancement in crop age up to 90 DAS and there after

increased gradually with decreasing rate up to harvest stage. The lower LAI and DMP were obtained when maize was cultivated under zero tillage with flat surface planting method of land configuration during both the years of study.

The maize yield parameters like number of rows per cob, number of grains per cob were significantly influenced by the tillage and land configuration methods whereas test weight was not significantly influenced by the different treatment combinations. During 2011-12, higher number of rows per cob was recorded in reduced tillage to both cotton and maize and planting on FIRB (14.06) and in 2012-13, conventional tillage once to cotton alone and planting on FIRB recorded higher value of 14.67 which was on par with conventional tillage to both cotton and maize and planting on ridges and furrows (14.49) and reduced tillage to both cotton and maize and planting on FIRB(14.09). Reduced tillage to both cotton and maize and planting on FIRB recorded higher number of grains per cob (480) and which was followed by conventional tillage to both cotton and maize and planting on FIRB (479) in 2011-12. Conventional tillage to both cotton and maize and planting on ridges and furrows registered higher number of grains per cob during 2012-13, which was followed by the conventional tillage to both cotton and maize and planting on FIRB (Table 2). The maize yield parameters were minimum when crops were planted on flat surface coupled with zero tillage or conventional tillage.

Maize grain and straw yield were significantly influenced by tillage practices with different land configuration during 2011-12 and 2012-13. Conventional tillage once to cotton and planting on FIRB registered higher grain yield of 8084 kg/ha which was statistically on par with conventional tillage to both cotton and maize and planting on ridges and furrows (7794 kg/ha), conventional tillage to both cotton and maize and planting on flat bed (7687 kg/ha), and reduced tillage to both cotton and maize and planting on FIRB (7610 kg/ha) during 2011-12 (Table 3). Whereas in 2012-13, conventional tillage to both cotton and maize and planting on ridges and furrows registered higher grain yield of 6638 kg/ha followed by conventional tillage once to cotton and planting on FIRB(6558 kg/ha), reduced tillage to both cotton and maize and planting on FIRB (6360 kg/ha) and conventional tillage to both cotton and maize and planting on flat bed (6094 kg/ha). Similar results are reported by Marwat *et al*. (2007) and Allah Wasaya *et al*. (2011). The maize grain yield was lesser when zero tillage or conventional tillage practices adopted with flat surface planting.

Table 1
Effect of Tillage and Land Configuration on Growth and Yield Parameters of Cotton

Treatments	*Growth parameters*				*Yield parameters*					
	2011-12		*2012-13*		*2011-12*			*2012-13*		
	LAI at 90 DAS	*DMP at harvest*	*LAI at 90 DAS*	*DMP at harvest*	*Sympodial branches (Nos.)*	*Bolls/plant (Nos.)*	*Boll weight (g)*	*Symbodial branches (Nos.)*	*Bolls/plant (Nos.)*	*Boll weight (g)*
T_1	2.15	4341	1.83	3751	13.34	40.80	5.34	14.05	30.37	5.45
T_2	2.89	5217	2.33	4639	16.66	44.90	5.12	15.43	33.01	5.65
T_3	2.75	5344	2.11	4730	17.21	48.20	5.19	16.40	33.67	5.64
T_4	2.05	4763	1.72	3867	13.73	41.50	4.92	13.57	32.00	5.25
T_5	2.78	5678	2.04	4804	17.41	45.57	5.29	15.92	36.00	5.72
T_6	2.66	5058	2.06	4539	15.43	42.57	5.39	15.43	33.95	5.52
T_7	1.88	4094	1.69	3549	13.14	36.27	4.44	13.63	28.33	4.82
T_8	2.72	5420	2.11	4813	16.85	46.53	5.14	15.43	35.67	5.02
SEd	0.24	354	0.13	392	1.17	3.24	0.36	0.81	2.22	0.39
CD(P=0.05)	0.50	739	0.27	819	2.45	6.76	NS	1.69	4.64	NS

T_1 : Conventional tillage to both cotton and maize and planting on flat bed
T_2 : Conventional tillage to both cotton and maize and planting on FIRB
T_3 : Conventional tillage once to cotton alone and planting on FIRB
T_4 : Reduced tillage to both cotton and maize and planting on flat bed
T_5 : Reduced tillage to both cotton and maize and planting on FIRB
T_6 : Reduced tillage once to cotton alone and planting on FIRB
T_7 : Zero tillage and planting on flat bed
T_8 : Conventional tillage to both cotton and maize and planting on ridges and furrows (existing practice as check)

Table 2
Effect of Tillage and Land Configuration on Growth and Yield Parameters of Maize

Treatments	*Growth parameters*				*Yield parameters*					
	2011-12		*2012-13*		*2011-12*			*2012-13*		
	LAI 60 DAS	*DMP at harvest*	*LAI 60 DAS*	*DMP at harvest*	*No. of rows/ cob*	*No. of grains / cob*	*100 seed weight (g)*	*No. of rows/ cob*	*No. of grains / cob*	*100 seed weight (g)*
T_1	3.18	11075	2.58	8967	12.80	395	43.08	12.33	304.81	40.42
T_2	3.82	14625	3.21	10091	14.06	479	44.53	13.81	397.48	40.23
T_3	3.99	15229	3.67	11746	13.87	479	45.73	14.67	390.90	41.97
T_4	3.01	10672	2.73	8122	12.60	401	42.78	12.92	319.78	41.25
T_5	3.71	14959	3.55	10618	14.06	480	45.13	14.09	383.31	42.07
T_6	3.53	12439	3.71	10209	13.47	471	45.42	13.85	375.76	41.72
T_7	2.99	9998	2.54	8043	12.33	362	43.42	12.94	315.02	39.23
T_8	3.75	14717	3.85	11704	13.82	469	45.47	14.49	397.65	40.11
SEd	0.25	684	0.21	791	0.49	28	3.21	0.68	24.70	3.65
CD(P=0.05)	0.52	1429	0.44	1653	1.03	579	NS	1.41	51.60	NS

Table 3
Effect of Tillage and Land Configuration on the Yield of Seed Cotton and Maize

Treatments	*Cotton*				*Maize*			
	2011-12		*2012-13*		*2011-12*		*2012-13*	
	Seed cotton yield (kg/ha)	*Stalk yield (kg/ha)*	*Seed cotton yield (kg/ha)*	*Stalk yield (kg/ha)*	*Grain yield (kg/ha)*	*Straw yield (kg/ha)*	*Grain yield (kg/ha)*	*Straw yield (kg/ha)*
T_1	2307	3423	2192	3113	7419	10789	4966	8171
T_2	2698	3838	2248	4208	7687	12425	6094	10300
T_3	2746	4286	2432	3838	8084	13045	6558	10961
T_4	2424	3380	2205	3277	6968	10655	5615	8698
T_5	2887	3954	2560	4087	7610	12025	6360	10039
T_6	2546	3689	2326	3624	7464	11700	5736	9561
T_7	2039	3154	1886	2651	6631	9767	4928	6721
T_8	2802	3919	2451	3965	7794	12909	6638	10487
SEd	107	232	95	346	362	687	265	954
CD(P=0.05)	224	485	202	724	757	1435	554	1993

Table 4
Effect of Tillage and Land Configuration on the Productivity and Economics of Cotton - Maize Cropping Systems

Treatments	*Cotton equivalent yield (kg/ha)*			*Cost of cultivation (Rs./ha)*			*Net return (Rs./ha)*			*B:C ratio*		
	2011-12	*2012-13*	*Mean*	*2011-12*	*2012-13*	*Mean*	*2011-12*	*2012-13*	*Mean*	*2011-12*	*2012-13*	*Mean*
T_1	4533	3627	4080	69135	87208	78172	112185	76007	94096	1.83	1.07	1.45
T_2	5004	4008	4506	67635	83108	75372	132525	97252	114889	2.22	1.39	1.81
T_3	5172	4327	4750	62310	76283	69297	144570	118432	131501	2.62	1.79	2.21
T_4	4514	3827	4171	64485	80708	72597	116075	91507	103791	2.03	1.36	1.70
T_5	5170	4397	4784	63385	78558	70972	143415	119307	131361	2.54	1.76	2.15
T_6	4785	3983	4384	60085	74008	67047	131315	105227	118271	2.37	1.67	2.02
T_7	4028	3310	3669	57085	71658	64372	104035	79104	91570	2.05	1.24	1.65
T_8	5141	4369	4755	67635	83108	75372	137245	115149	126197	2.30	1.58	1.94
SEd	195	115	155									
CD(P=0.05)	407	240	324									

Cotton Equivalent Yield (CEY)

The maize grain yield was converted into equivalent yield of cotton and cotton equivalent yield (CEY) for the cotton - maize cropping systems was worked out. The CEY was significantly influenced by the tillage and land configuration practices during both the years of study. During 2011-12, conventional tillage once to cotton alone and planting on FIRB (5172 kg/ha) and reduced tillage to both cotton and maize and planting on FIRB (5170 kg/ha) registered identical higher CEY which was statistically on par with conventional tillage to both cotton and maize and planting on ridges and furrows (5141 kg/ha) and reduced tillage once to cotton alone and planting on FIRB (4785 kg/ha) (Table 4). During 2012-13, reduced tillage to both cotton and maize and planting on FIRB registered higher CEY of 4397 kg/ha and it was on par with conventional tillage to both cotton and maize and planting on ridges and furrows (4369 kg/ha) and RT once to cotton alone and planting on FIRB (4327 kg/ha). The lowest CEY was obtained in zero tillage with flat surface planting (4028 and 3310 kg/ha during 2011-12 and 2012-13). Average of the two years resulted that the CEY was almost similar in reduced tillage to both cotton and maize, and planting on FIRB (4784 kg/ha), existing practice of conventional tillage to both cotton and maize, and planting in ridges and furrows (4755 kg/ha) and conventional tillage to cotton alone and planting both cotton and maize on the FIRB (4750 kg/ha).

Economics

In cotton - maize cropping system as a whole, highest net return (Rs.144570 ha^{-1}) and B-C ratio (2.62) was realised with conventional tillage once to cotton alone and planting on FIRB and it was closely followed by reduced tillage to both cotton and maize and planting on FIRB (net return: Rs.143415 ha^{-1}; B-C ratio: 2.54) during 2011-12. Whereas in 2012-13, highest net return of Rs.119307 ha^{-1} was realised in reduced tillage to both cotton and maize and planting on FIRB with the B-C ratio of 1.76. This was followed by conventional tillage once to cotton alone and planting on FIRB (net return: Rs.118432 ha^{-1}; B-C ratio: 1.79). The lower net return of Rs.104035 and 76007 ha^{-1} were recorded in zero tillage with flat surface planting during 2011-12 and conventional tillage to both cotton and maize and planting on flat bed during 2012-13, respectively. In cotton - maize cropping systems, the higher profitability in conventional tillage or reduced tillage with FIRB was mainly due to reduced fuel, water and labour costs while maintain the same yield levels. This result was in accordance with Jat *et al*. (2006).

Average of the two years data revealed that conventional tillage to cotton alone and planting both cotton and maize on the FIRB recorded the highest net return (Rs.1,31,501/ha/year) and B-C ratio (2.21) followed by reduced tillage to both cotton and maize and planting on FIRB (Rs.1,31,361/ha/year) and existing practice of conventional tillage to both cotton and maize and planting in ridges and furrows (Rs.1,26,197/ha/year).

ACKNOWLEDGEMENT

The authors are thankful to the Project Directorate for Farming Systems Research (PDFSR), Modipuram, Meerut (UP) for providing the technical and financial help.

REFERENCES

Abaye, A.O., Maitland, J.C. and Wilkinson, W. B. (1995), Influence of cover crops and tillage practices on yield and quality of cotton. Proc. Beltwide Cotton Conf. 1349. Natl. Cotton Council, Memphis, TN.

Aydin Unay, Engin Tan,Cahit Konak and Esen Celen. (2005), Influences of winter cover crop residues and tillage on cotton lint yield and quality. *Pak. J. Bot.,* 37(4): 905-911.

Jat, M. L., Sharma, S. K., Rai, H. K., Srivastava, A. and Gupta. R. K. (2006), Effect of tillage on performance of winder maize in Northern India. Maize Association of Australia. 6th Triennial Conference.

Marwat, K.B., Arif, M. and Khan, KA. (2007), Effect of tillage and Zinc application methods on weeds and yield of maize. *Pak. J. Bot.,* 39(5): 1583-1591.

Reicosky, D.C., Saxton, K.E. (2007), Reduced environmental emissions and carbon sequestration. In: Baker, C.J. Saxton, K.E. editors. No-tillage seeding in Conservation Agriculture. 2nd edition. Rome, Italy: FAO and CAB International. pp. 257-267.

Übrahim Yalin, Aydyn nay and Rauf. (2005), Effects of reduced tillage and planting systems in seed cotton yield and quality parameters. *Turk J. Agric.,* 29: 401-407.

Veer Singh, Shri Ram, Amit Bhatnagar and Uma Shankar Savita. (2011), Effect of tillage methods on soil properties and productivity of quality protein maize (*Zea mays* L.) - Wheat (*Triticum aestivum L.*) system. *Indian J. Agron.,* 56(2): 83–87.

Meenakshi Gupta, S. Amarjit Bali, Sarabdeep Kour, Rajeev Bharat and Bazaya, B. R. (2011), Effect of tillage and nutrient management on resource conservation and productivity of wheat (*Triticum aestivum*). *Indian J. Agron.,* 56(2): 116-120.