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Effect of Resource Conservation Technologies against Climate Change for Higher Productivity of Summer Greengram (*Vigna radiata* (L.) Wilczek)

T. Pandiaraj[1]*, A.K. Bhardwaj[2] and Sumit Chaturvedi[2]

[1]Central Tasar Research and Training Institute, Ranchi, Jharkhand – 835 303, India
[2]Department of Agronomy, G.B.P.U.A. &T., Pantnagar - 263 145, Uttarakhand, India
**Corresponding author*

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A B S T R A C T

Field experiment was conducted during summer season of 2012 and 2013 at the N. E. Borlaug Crop Research Centre, G. B. Pant University of Agriculture and technology, Pantnagar, U. S. Nagar (Uttarakhand) to study the effect of different resource conservation technique (RCT) practices on the growth and yield of greengram. Treatments consisted of two levels of tillage system i.e. conventional tillage (CT) and reduced tillage (RT) with and without paddy straw mulching in main plots and two level of fertility (100 and 75% RDF) in sub plots and were laid out in factorial split plot design with three replications. The results of the experiments revealed that plant growth of greengram was increased with RCT over conventional management practices. Conventional tillage promoted higher root length than reduced tillage however, root dry matter and functional root nodules were higher in reduced tillage. Both straw mulch and 100% RDF increased root length, dry matter and functional nodules of greengram. Reduced tillage practices favoured the greengram seed yield. In general, yield was better when applied with paddy straw mulch along with 100% RDF during summer season of 2012 and 2013.

Introduction

Traditionally pulses have been considered important elements of cropping systems in the Indo- Gangetic Plains. They were popular because of their importance as a source of protein and ability to fix atmospheric nitrogen (N) and thus improve soil fertility (Joshi, 1998). With the introduction of irrigation and due to high profitability of alternative sources of soil nutrients in the form of inorganic fertilizers in the mid-1960s, legumes were replaced or relegated to marginal lands. During the late 1960s and early 1970s, a large area under legumes in the Indo-Gangetic Plain (IGP) was substituted by high- yielding varieties of rice (*Oryza sativa*) and wheat (*Tritium aestivum*). The new technology of rice and wheat substantially changed the agricultural scenario and largely contributed to increase in agricultural production in the IGP.

With the passage of time, excessive use of chemical fertilizers and irrigation in rice and wheat to maintain their productivity has created an imbalance in soil fertility and threatened the sustainability of the most productive food grain belt in IGP (Hobbs and Morris, 1996). Legumes are an effective source of reversing the process and can contribute significantly to achieving the twin objectives of increasing productivity and improving the sustainability of the rice and wheat- based cropping system in the IGP (Ahlawat *et al*., 1998; Lauren *et al*., 1998).

The area under pulses in India is around 24.38 million hectares with a production of 14.52 million tonnes with average 6.79 q ha^{-1}. Nearly 8 per cent of this area is occupied by greengram (*Vigna radiata)*, which is the third important pulse crop of India in terms of area cultivated and production next to gram and pigeon pea. In Uttarakhand, greengram is cultivated in an area of 31 thousand hectares with an annual production of 24.4 thousand tonnes (DOA, 2011). The state productivity of the crop is only 427 kg ha^{-1}. This low yield is attributed to several reasons however, mainly due to faulty management practices following in conventional agriculture such as tillage, nutrient and weed management practices and decline in soil fertility play a major role in realizing the potential of a given variety along with other contributing factors. To exploit the full genetic potentiality of any greengram variety, development of management technology would become utmost important. Under the use of improved crop management practices, greengram responded markedly to resource conservation technology (RCT) and mineral nutrition especially, when applied in sufficient amount and by appropriate methods.

RCT can contribute in making agricultural system more resilient to declining total factor productivity as well as could make sustainable production of greengram. Among the RCT, minimum disturbance of soil through reduced tillage, soil cover through mulching and diversified crop through legumes is major principles and becoming popular in alternative to rice-wheat system and has potential to cover a large area in the IGP plains. Mupangwa *et al.,* (2012) reported that greengram planted with mulching significantly produced the highest seed yield. Sharma *et al.*, (2002) reported that the summer greengram raised in loamy sand with minimum tillage recorded 15 per cent higher yield over conventional tillage system. Though, numerous research are well documented on RC practices only few studies have been made involving all the components of conservation agriculture together i.e. minimum disturbance, residue cover and diversification in other crops especially legume crops. In this backdrop, it was thought worthwhile to develop an agronomically appropriate RCT management practices on the growth and yield of greengram in the Tarai region of Uttarakhand.

Materials and Methods

A field experiment was conducted during summer season of 2012 and 2013 at the N. E. Borlaug Crop Research Centre, G. B. Pant University of Agriculture and technology, Pantnagar, U. S. Nagar (Uttarakhand) to study the effect of different resource conservation techniques (RCT) practices on the growth and yield of greengram (*Vigna radiata* (L.) Wilczek). The site lies at 29^{o}N latitude and 79.3^{o}E longitude at an elevation of 243.8 m above mean sea level. The soil is loam in texture. Soil chemical properties showed that the soil was medium in organic carbon, low in available nitrogen, medium in available phosphorus and potassium and neutral in soil reaction.

The experiment comprised all 24 factorial combinations of two tillage systems *i.e.* conventional tillage (CT) and reduced tillage (RT) and two mulch treatments i.e. with and without paddy straw mulching in main plots and two level of fertility (100 and 75% RDF) in sub plots were laid out in factorial split plot design with three replications. The land was ploughed in CT system by three times harrowing with tractor drawn disc harrow followed by 2-3 times planking and incase of RT, the land was ploughed by one rotavator followed by one planking. The sundry rice straw mulch of 7.5 t ha^{-1} was used as mulching material after chopped into 3-5 inch pieces. Rice straw was spread manually over the soil surface to cover at least 80% of the ground area just after sowing to prevent initial soil moisture loss from mulched plots. The recommended dose of fertilizers per hectare was 25-50-0 kg NPK applied in the form of urea and 10-26-26 complex fertilizers. All fertilizers were uniformly applied in the field after just before sowing of greengram. The greengram variety 'Pant Moong -5' was sown with spacing of 30 × 10 cm on second fortnight of February and harvested on first fortnight of May. The crop was irrigated uniformly to bring the soil moisture near to field capacity at 7-10 days intervals for both the years.

All the shoot, root growth were measured during harvesting time. Roots with soil were collected from five randomly selected plants from each plot. Root length was estimated using direct measurement and expressed in cm. Functional root nodules were counted in five plants selected from the sample rows at harvest time and expressed in number $plant^{-1}$. The root samples were oven dried at 70°C for 72 h and weighed to determine dry weight and expressed in g $plant^{-1}$. Data was analyzed by three-factor analysis using OPSTAT software package. Treatment means were tested at 5% level of significance (SPSS 16.0). Further statistical validity of the differences among treatment means was estimated using the least significant differences (LSD) comparison method.

Results and Discussion

Growth attributes

The effect of tillage, mulch and N levels was always significant in relation to plant height during 2013 as compared to 2012 where significant effect was exhibited only at harvest stage (Table 1). Tillage systems had significant effect at harvest stage during 2012; whereas during 2013, tillage was significantly influenced on all the stages. Plant height of conventionally tilled greengram performed higher upto 60 DAS thereafter RT recorded higher plant height than CT during both the years.

Plant height in mulched plot was comparatively taller than unmulched plots in all the stages during 2012 and 2013 however; height of initial stages i.e.30 and 60 DAS during 2012 were no significant difference between mulch and no-mulch treatments. Fertility levels resulted in significant difference for the plant height in all the growth stages during both the years except on 30 DAS during 2012. In general, during the two years of the study and during all growth stages, the plant height increased with fertility level of 100% RDF as compared to 75% RDF.

During both the years, mulch and fertility levels had significant effect on drymatter accumulation of greengram in all the growth stages whereas, tillage systems exhibited significant effect only on 30 and 60 DAS during 2012 and 60 DAS during 2013 (Table 1). Generally, the same trend was observed as in plant height of greengram.

Initial dry matter accumulation was considerably increased up to 60 DAS in CT greengram however, at harvest stage, both CT and RT resulted in similar response to accumulation of dry matter. The greengram dry matter production significantly increased with mulch at all the stages during 2012 and 2013. Similarly, fertilizer 100% RDF application had significantly influenced and produced higher dry matter on all the stages during both the years as compared to 75% RDF application.

Yield and yield components

In 2012 and 2013, all the yield components (no. of seeds per pod, no. of pods per plant and thousand seed weight) and grain yield per hectare tended to be slightly higher in RT than in CT, though not significantly (Table 2). However, no. of seeds per pod during both the years and no. of pods per plant were significantly influenced by tillage systems. Whereas, mulching significantly increased yield and yield components during both the years as compared to no-mulch treatments. Similarly, plots fertilized with 100% RDF had significantly increased yield and yield components than 75% RDF application treatment during 2012 and 2013.

Root characteristics

Root length

Roots were longer in greengram raised during 2013 than 2012 (Table 3). Generally, the root length increased significantly with RCT practices in both the years. In addition, the root length under CT (27.3 and 28.2 cm) was significantly higher than under RT (25.0 and 25.4 cm) during 2012 and 2013, respectively. Mulching significantly influenced root length during both the years, soil covered with straw mulch resulted in significantly longer roots than the no-mulch plots. Similarly, application of 100% RDF favored longer roots as compared to 75% RDF application.

Root dry weight

The dry matter accumulation in roots increased with RCT practices during both the years (Table 3). However, the root dry weight in 2013 was higher over 2012. The root dry weight in both the years was recorded higher with RT than with CT. Mulching and application of 100% RDF significantly increased root dry weight than no-mulch and application of 75% RDF treatment in all the years.

Functional root nodules

Functional root nodules were more during summer 2013 than the 2012 (Table 3). The tillage systems influenced the functional root nodules during both the years. Greengram raised in RT recorded more number of functional root nodules per plan than raised in CT. similarly mulched greengram resulted in higher number of root nodules as compared to no-mulch treatments. Applications 100% RDF level recorded significantly higher number of functional root nodules during both the years and 75% RDF recorded lower numbers in functional root nodules of greengram.

Though green gram in CT produced higher initial growth and dry matter production, greengram in RT performed superior than CT at later stage of crop growth. There was significant interaction between tillage x mulch and tillage x fertility. Ncube *et al*., (2009) reported application of mulch increased soil nutrient status and decreased soil bulk density resulted in higher crop growth than bare soil. Our results also showed that mulched greengram crop increased crop growth as compared to no mulched crop during both the years and this was significantly interacted with tillage systems.

This might be attributed to CT practices provide a favorable environment condition to grow greengram under CT plot but in the later stages, RT with mulch contributed higher mass of roots and root nodules. Therefore, RT with mulching treatments resulted in fixing more biological N fixation than CT and increased nutrient pool in the soil. Sharma and Acharya (2000) suggested that longer rooting and soil moisture conserve in straw mulch benefits and led to better crop growth. Hence, RT has been exhibited higher plant growth at harvest stage.

Table1 Crop growth of greengram at various growth stages as influenced by different RCT practices during 2012 and 2013

Treatments		Plant height (cm)						Dry matter (g m^{-2})					
		2012 (DAS)			2013 (DAS)			2012 (DAS)			2013 (DAS)		
		30	60	Harvest	30	60	Harvest	30	60	Harvest	30	60	Harvest
Tillage systems (T)													
Reduced tillage		12.4	46.4	55.9	14.0	38.4	55.9	66.6	292	350	66.3	280	348
Conventional tillage		14.6	47.5	53.7	16.0	41.5	53.8	70.7	305	350	67.3	307	344
SEm.±		0.67	0.31	0.35	0.16	0.22	0.37	0.3	3.14	3.02	0.37	2.07	3.39
LSD at 5 %		NS	NS	1.20	0.56	0.76	1.29	1.0	10.8	NS	NS	7.15	NS
Mulch (M)													
No mulch		12.7	44.2	53.2	13.8	35.4	51.7	54.3	254	338	54.6	255	332
Straw mulch		14.3	49.7	56.4	16.2	44.6	58.1	82.9	343	362	79.0	331	360
SEm.±		0.67	0.31	0.35	0.16	0.22	0.37	0.31	3.14	3.02	0.37	2.07	3.39
LSD at 5 %		NS	NS	1.20	0.56	0.76	1.29	1.05	10.8	10.4	1.26	7.15	11.7
Fertility levels (F)													
100% RDF		14.6	48.3	55.8	15.6	41.3	56.5	71.8	315	371	69.3	309	360
75% RDF		12.4	45.6	53.8	14.4	38.7	53.2	65.4	282	329	64.3	277	333
SEm.±		0.78	0.51	0.27	0.06	0.22	0.52	0.64	2.19	1.74	0.46	1.67	2.85
LSD at 5 %		NS	1.67	0.87	0.19	0.73	1.70	2.08	7.13	5.68	1.49	5.45	9.28
Interaction effect between different treatments													
T × M	SEm.±	0.95	0.44	0.49	0.23	0.31	0.53	0.43	4.43	4.3	0.52	2.93	4.80
	LSD at 5 %	NS	1.52	1.69	0.78	1.08	NS	1.49	NS	14.7	NS	10.1	16.5
T × F	SEm.±	1.11	0.73	0.38	0.08	0.41	0.74	0.90	3.10	2.47	0.65	2.37	4.03
	LSD at 5 %	NS	NS	NS	0.26	NS	NS	NS	10.1	NS	NS	7.71	NS
M ×F	SEm.±	1.11	0.73	0.38	0.08	0.41	0.74	0.90	3.10	2.47	0.65	2.37	4.03
	LSD at 5 %	NS	NS	NS	NS	NS	NS	2.93	NS	NS	NS	NS	NS
T × M × F	SEm.±	1.56	1.03	0.53	0.12	0.58	1.04	1.27	4.38	3.49	0.91	3.35	5.70
	LSD at 5 %	NS	NS	NS	NS	NS	NS	NS	NS	11.4	NS	10.9	NS

Table.2 Yield and yield attributes of greengram as influenced by different RCT practices during 2012 and 2013

Treatments		No. of seeds Pod^{-1}		No. of pods $plant^{-1}$		1000 seed weight		Grain yield (kg ha^{-1})	
		2012	2013	2012	2013	2012	2013	2012	2013
Tillage system (T)									
Reduced tillage (RT)		8.59	8.93	32.5	32.8	30.3	31.3	8.87	8.89
Conventional tillage (CT)		8.16	8.19	30.1	32.5	30.3	31.2	8.77	8.82
SEm.±		0.09	0.05	0.23	0.25	0.17	0.22	0.03	0.08
LSD (P=0.05)		0.29	0.16	0.80	NS	NS	NS	NS	NS
Mulch (M)									
No- mulch		7.89	8.19	30.1	30.8	28.9	29.7	8.25	8.31
Straw mulch		8.86	8.93	32.6	34.5	31.7	32.8	9.22	9.41
SEm.±		0.09	0.05	0.23	0.25	0.17	0.22	0.03	0.08
LSD (P=0.05)		0.29	0.16	0.80	0.86	0.60	0.75	0.12	0.26
Fertility levels (F)									
100% RDF		8.84	8.99	34.3	35.8	31.2	32.3	8.88	9.05
75% RDF		7.91	8.13	28.4	29.5	29.4	30.2	8.59	8.66
SEm.±		0.05	0.10	0.23	0.12	0.16	0.25	0.05	0.05
LSD (P=0.05)		0.16	0.33	0.76	0.39	0.51	0.82	0.17	0.16
Interaction effect between different treatments									
T × M	SEm.±	0.12	0.06	0.33	0.35	0.25	0.31	0.05	0.11
	LSD (P=0.05)	0.42	NS	1.13	1.21	0.85	NS	0.17	NS
T × F	SEm.±	0.07	0.14	0.33	0.17	0.22	0.35	0.08	0.07
	LSD (P=0.05)	0.22	NS	1.08	0.55	0.72	NS	NS	NS
M × F	SEm.±	0.07	0.14	0.33	0.17	0.22	0.35	0.08	0.07
	LSD (P=0.05)	0.22	NS	1.08	0.55	NS	NS	NS	NS
T × M × F	SEm.±	0.10	0.20	0.47	0.24	0.31	0.50	0.11	0.09
	LSD (P=0.05)	NS	NS	NS	0.78	NS	1.63	NS	NS

Table.3 Root characteristics of greengram as influenced by different RCT practices during 2012 and 2013

Treatments		Root length (cm)		Root dry weight (g plant^{-1})		No. of nodules plant^{-1}	
		2012	2013	2012	2013	2012	2013
Tillage system (T)							
Reduced tillage (RT)		25.0	25.4	0.95	1.05	17.6	18.3
Conventional tillage (CT)		27.3	28.2	0.86	0.87	16.4	17.3
SEm.±		0.16	0.10	0.01	0.01	0.16	0.16
LSD (P=0.05)		0.54	0.36	0.03	0.04	0.56	0.56
Mulch (M)							
No- mulch		23.8	23.2	0.75	0.78	15.6	15.7
Straw mulch		28.4	29.9	1.06	1.14	18.4	20.0
SEm.±		0.16	0.10	0.01	0.01	0.16	0.16
LSD (P=0.05)		0.54	0.36	0.03	0.04	0.56	0.56
Fertility levels (F)							
100% RDF		27.6	27.5	1.00	1.01	18.4	18.8
75% RDF		24.7	25.6	0.81	0.92	15.6	16.8
SEm.±		0.23	0.22	0.01	0.08	0.10	0.11
LSD (P=0.05)		0.76	0.72	0.02	0.03	0.34	0.35
Interaction effect between different treatments							
T × M	SEm.±	0.22	0.15	0.01	0.02	0.23	0.29
	LSD (P=0.05)	0.77	NS	0.04	0.06	0.80	0.77
T × F	SEm.±	0.33	0.31	0.01	0.01	0.15	0.15
	LSD (P=0.05)	NS	NS	NS	NS	0.49	0.50
M × F	SEm.±	0.33	0.31	0.01	0.01	0.15	0.15
	LSD (P=0.05)	NS	NS	0.03	NS	NS	0.49
T × M × F	SEm.±	0.46	0.44	0.02	0.02	0.21	0.21
	LSD (P=0.05)	NS	NS	0.05	0.05	NS	NS

Fig.1 Interaction effects between tillage × mulch on grain yield (q ha^{-1}) of greengram during 2012. Error bars represent standard error. Treatments means followed by common letter (s) are not significantly different among each other by DMRT at *P* = 0.05 level of significance

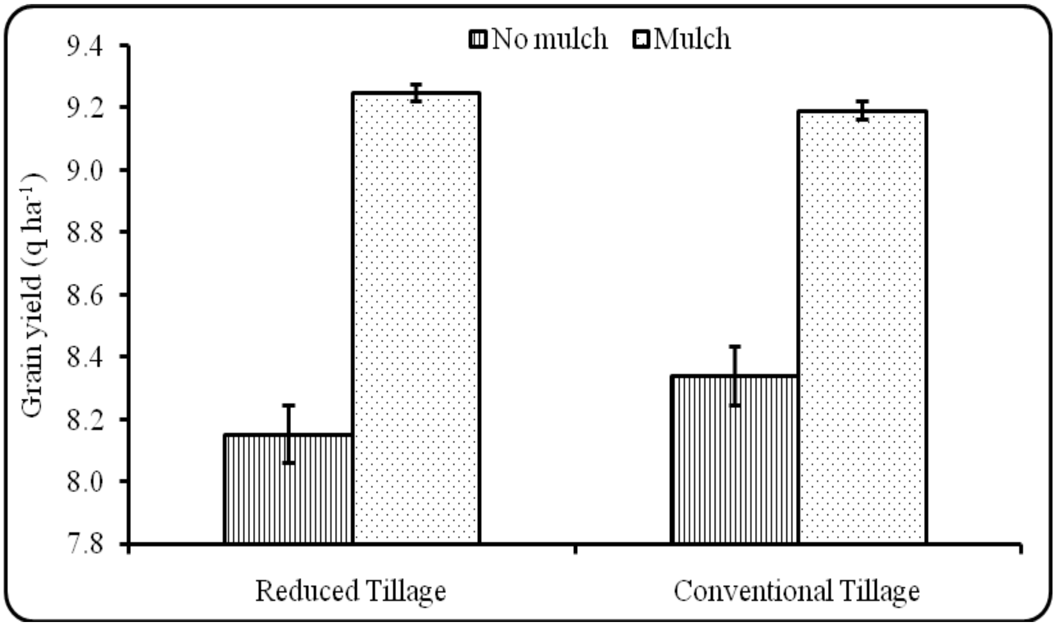


Fig.2 Interaction effects between tillage × mulch on root length (cm) of greengram during 2012. Error bars represent standard error. Treatments means followed by common letter (s) are not significantly different among each other by DMRT at *P* = 0.05 level of significance

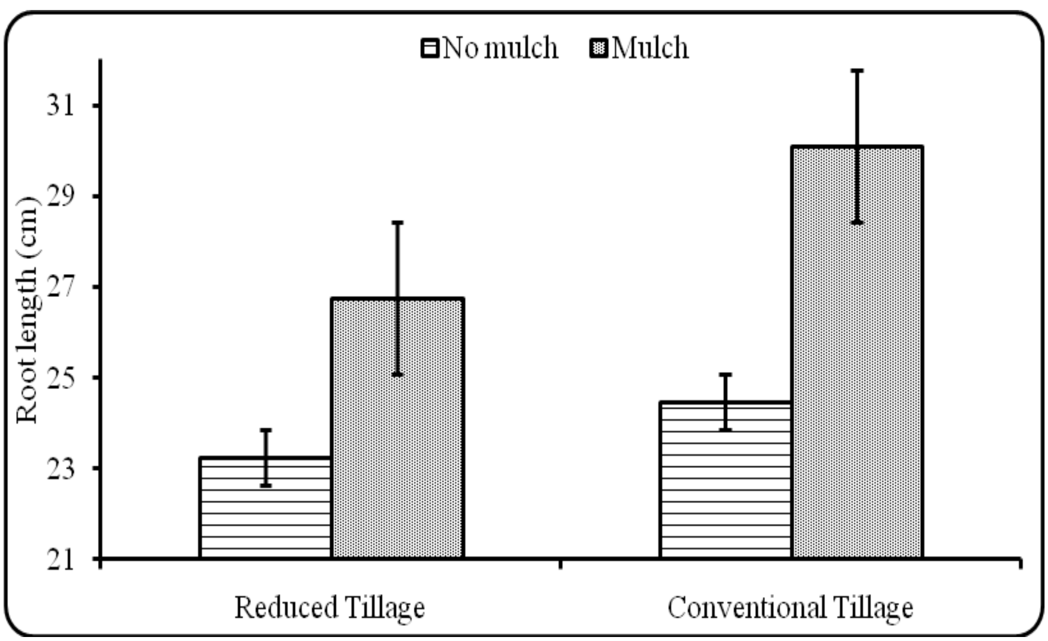


Fig.3 Interaction effects of tillage × mulch × fertility on root dry weight (g plant^{-1}) of greengram during 2012. Error bars represent standard error. Treatments means followed by common letter (s) are not significantly different among each other by DMRT at P = 0.05 level of significance

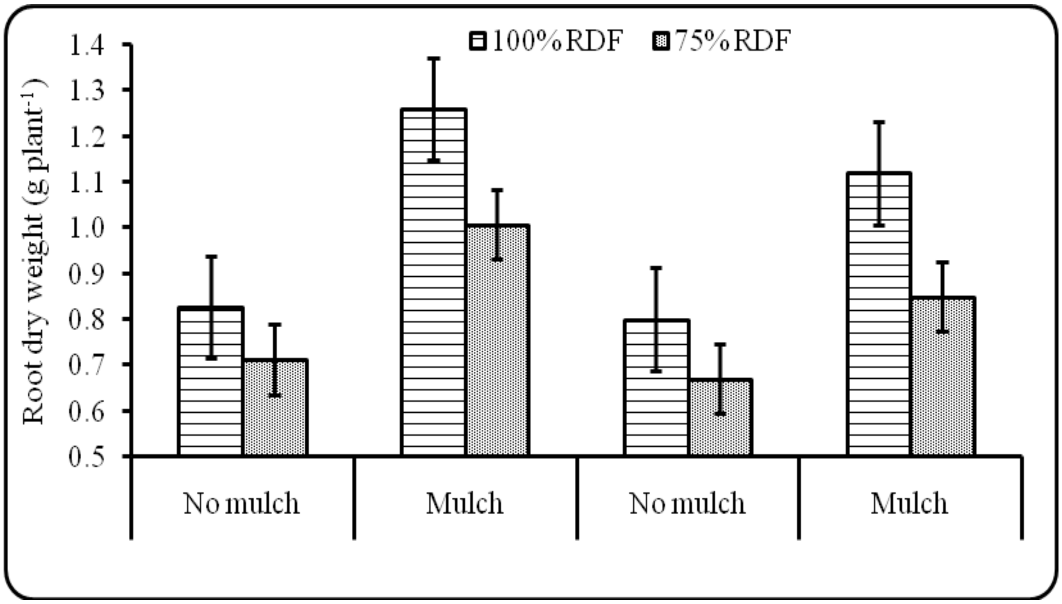
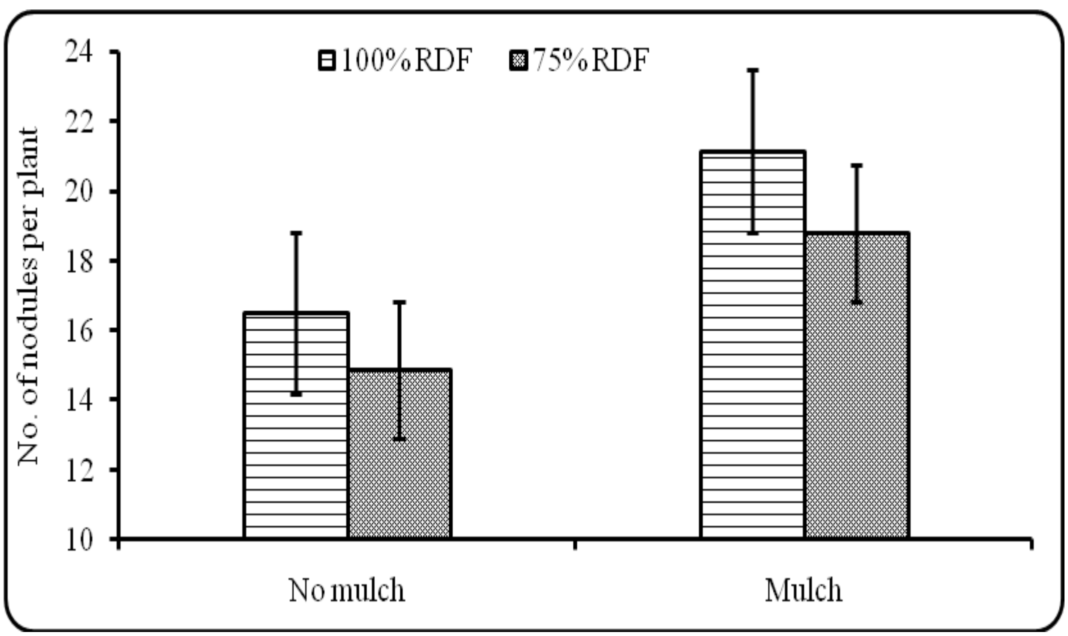


Fig.4 Interaction effects between mulch × fertility on no. of nodules per plant of greengram during 2013. Error bars represent standard error. Treatments means followed by common letter (s) are not significantly different among each other by DMRT at P = 0.05 level of significance.



Lower plant growth under CT treatments might be due to more nutrient loss and was more susceptible to soil erosion along with soil nutrient and higher mineralization of stored organic matter due to repeated tillage in CT.

Therefore, the plant takes up less nutrients from soil and reduced plant growth. Similar results were also confirmed by Rao and Mathuva, (2000); Ncube *et al*., (2009).

Our investigation from both the years resulted that most of the yield attributing characters are not significantly varied between tillage systems. Therefore, showed non-significant in relation to seed yield between two tillage systems but RT slightly increased seed yield and yield components during both the years, however, mulch and application of 100% RDF levels significantly influenced higher grain yield than unmulched and 75% RDF application. There was significant interaction between tillage x mulch and which showed that non-significant influence within the treatment practices (mulch between conventional and reduced tillage and no-mulch between conventional and reduced tillage) (Fig. 1). The favourable effect of mulching was observed at reduced tillage. However, in case of tillage with no-mulch treatment, CT preformed better in producing higher grain yield over RT. This might be due to RT showing synergy and mutual benefit with mulch treatment in performing better productivity of greengram. RT along with residue mulch resulted to enhance the yield level of crop due to associated effects like prevention of soil degradation, improved soil fertility, improved soil moisture regime (due to increased rain water infiltration, water holding capacity and reduced evaporation loss) and crop rotation benefits. Mupangwa *et al.*, (2012) reported from their experiments, the RT systems gave more grain as compared to the conventional system along with mulch level used.

All the RCT practices resulted in better root growth except root length. CT system had observed higher root length. There was significant interaction between tillage x mulch on root length. Mulch in CT resulted in longer root length followed by mulch in RT (Fig. 2). This was due to better availability of water and aeration near the root; which encourages plant for developing a stronger root system in mulching plot (Khurshid *et al*., 2006). The use of mulches not only improved the soil bulk density but also reduced the compaction of soil that might have enhanced the aeration and microbial activities in the soil thus resulting in increased root penetration and cumulative feeding. Large numbers of root mass in RT were noticed on the surface whereas; the root penetration was lesser due to the compactness of the soil. Significantly higher root dry weight has been recorded with respect of mulch along with a combination of 100% RDF under RT followed by mulch + 100% RDF in CT practices (Fig. 3). This might be due to the addition of full doses of N, P and K applied along with paddy straw residue as mulch in minimum tillage in the initial stages that might have helped in the formation and growth of roots during crop growth stages. Even though RT had been recorded lower root length, most of the root biomass and lateral branches of roots were observed under the soil surface due to compaction in soil beneath as compared to CT. The mulching effect has resulted reduced compaction, bulk density and alleviates the root growth problems under RT. Therefore, more root length and root dry weight have been observed with this treatment. The usefulness of N supplement along with residue retention for growth of roots and formation of nodules under conservation tillage has been enlightened by Das (2009). An interaction between mulch × fertility, mulch along with 100% RDF observed significantly higher root nodules per plant (Fig. 4). Use of mulches with the addition of higher fertilizer not only improved the bulk density but also reduced the compaction of soil that might have enhanced the aeration and microbial activities in the soil thus resulting to increased root nodules and cumulative feeding. The findings on root parameters are in line with the observations of Mbah *et al*., (2010).

In conclusion field studies conducted on resource conservation techniques in tarai regions of Uttarakhand revealed that with appropriate RCT particularly reduced tillage with residue retention and 100% RDF fertilizer application, it is possible to increase higher growth and improved productivity. This will improve the farmer's income, put in use of on-farm resources and ultimately ensure food security in marginal areas in this region. Reduced tillage with residue retention not only favourably moderated the soil rhizosphere and produced higher grain yield in long-term perspective, but also keep clean environment through adoption of RCT.

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