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Influence of Tillage and Mulch on Growth, Yield, Root Characters and Soil Moisture Dynamics of Pea (*Pisum sativum*) in Arunachal Pradesh

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Experiments were conducted consecutively for three seasons (2008-09, 2009-10 and 2010-11) during October-January to study the effect of tillage and mulch on growth, yield and root characters of pea in Arunachal Pradesh. Two tillage methods, conventional tillage (CT) and zero tillage (ZT) as main plot and four mulches *viz*. paddy straw mulch (PSM), maize stubble (MS), *Imperata cylendrica* (thatches grass; TG) each at 4.0 t/ha and no mulch (NM) as sub plot in split plot design was executed. Pooled data of three years indicated that growth characters *viz*. plant height, number of branches/plant and total dry weight/plant along with nodule number and nodule dry weight/plant and yield attributes *viz*. number of pods/plant, pod length and seeds/pod were significantly higher with CT over ZT. Among the mulches, the growth and yield characters were higher with PSM followed by MS. Similarly, green pod, seed and stover yield were 11.1, 7.8 and 10.0% higher with CT over ZT. Among the mulches, PSM recorded 36.1, 34.3, and 24.8% more green pod, seed yield and stover yield over NM respectively. Higher root length (30.9%), root dry weight (19.7%) and root volume (24.7%) was observed with CT over ZT. In contrary, root numbers was 27.0% lower with CT.

Key words: Mulch, *Pisum sativum*, root characters, soil moisture, tillage, yield

The North East Hilly Region (NEHR) is characterized by diverse agro-climatic and geographical conditions. On the steep slope, continuous removal of top soil leads to poor to medium organic matter status. Soil tillage is one of the fundamental field operations in agriculture because it influences on soil properties, environment and crop production. Tillage systems are site-specific and depend on crop, soil type and the climate. Tillage affects water contents, aeration and available carbon (Saha *et al*., 2010), which in turn, can impact nitrogen loss through denitrification and N_2O emissions. No-tillage with standing stubble conserves soil organic matter and water and generally increases crop production (Tomar *et al*., 2006). Tillage practices that maintain crop residue on the soil surface have shown higher yield (Matula, 2003).

Similarly, the crop residues can be placed in soil, which act as mulch and having good effects. The positive effects of mulching on the moisture-, heat- and air regime of the soil are indisputable. The more favourable water regime manifested in higher yields makes mulching not only soil protective, but economically favourable as well (Suresh Kumar *et al*., 2012). Changes in soil organic carbon (SOC) are slow and small compared with the total amount of SOC present in agricultural soils, and due to inherently high spatial variability of SOC (Campbell *et al*., 2007). Farmers in this region, grows only rice during April to September/October and keep their land fallow during rest of the year. Basic idea behind this study was to take the second crop which is leguminous in nature and can utilize the residual soil moisture. Therefore, pea was selected as test crop and different mulch materials were used to evaluate the effect of tillage and mulches on pea yield, root characters and moisture content in soil profile.

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Materials and Methods

Field experiment was carried out in loamy soil at the experimental farm of ICAR Research Complex for NEH Region, Arunachal Pradesh Centre, Basar, located at West Siang District of Arunachal Pradesh, India during 2008-09, 09-10 and 10-11. The daily temperature varied between minimum 4^{0}C and maximum 35^{0}C with an average annual rainfall of 2400 mm with high degree of temporal and spatial variations (Fig. 1). The experiment was laid out in split plot design and replicated thrice. Tillage practices were allocated in main plot and mulches were placed in sub plot. The details of the tillage practices were conventional tillage (CT) where, land was disc ploughed to 25 cm-depth, subsequently land were disked using tractor-drawn rotary disc. Zero till system (ZT) where a hand hoe was used to open planting stations. Details of the mulch placement were; paddy straw mulch (PSM; 4.0 t/ha), maize stalk (MS; 4.0 t/ha), thatches grass (*Imperata cylindrica*; TG; 4.0 t/ha) and no mulch (NM). Pea variety Azad pea 1 was sown in the spacing of 30 x 10 cm in given tillage treatments and mulch materials were placed 10 days after

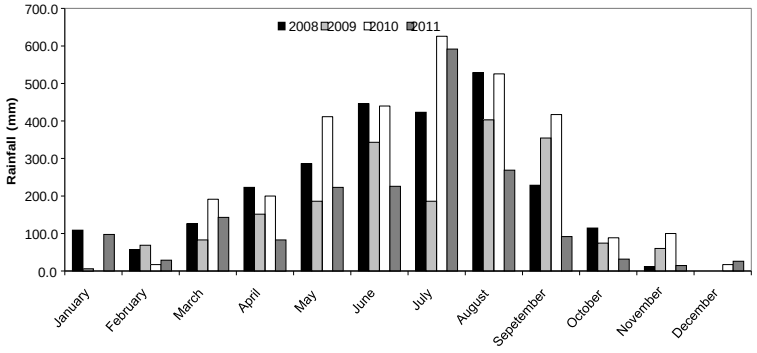

Fig. 1. Rainfall distribution of the experimental site during the study period

sowing. Crop was supplied with 20 kg nitrogen and 60 kg phosphorus and 40 kg potassium/ha through urea, single super phosphate and muriate of potash respectively as basal dose. Other cultivation practices were carried out as per the scientific recommendation for the region.

Data on Plant height, number of branches/plant, total dry matter, number of pods/plant, pod length, number of seeds/pod were recorded from randomly selected five tagged plants. Nodule number and nodule dry weight was recorded at 60 DAS. The root sample was collected carefully from the field at the time of harvest and following root parameters viz., maximum root length, root numbers, root volume, root dry weight and root density were recorded. Water content at field was measured by gravimetric method at 0-10, 10-20 and 20-30 cm soil depths.

Results and Discussion

Growth characters

Plant height, number of branches and total dry matter were the highest with CT followed by ZT (Table 1). CT recorded higher plant height, number of branches and dry matter accumulation (11.5, 17.6 and 10.8%, respectively) over ZT. Similar finding was also reported by Diaz-Zorita (2000), who concluded that shoot dry matter was significantly higher in the tilled soil than those under ZT. Higher availability of soil water, better root growth and nutrient uptake was witnessed in CT than ZT. Compactness of soil in ZT prevents the root growth, uptake of nutrients and led to water uptake from the limited surface. Among mulches, PSM, MS and TG recorded higher plant height (23.0, 19.9 and 14.8%) and dry matter (52.0, 43.5 and 33.7%) respectively over NM. The application of mulches during post rainy season encourage the plants for excellent crop growth (Sarkar *et al*. 2007). Availability of water through retention for longer time under PSM and MS helped the plant to grow better and produce more number of branches which in turn led to higher dry matter production and accumulation in different productive plant parts. Similar finding on maize was also reported by Mbah *et al*. (2010).

Nodulation in pea

Tillage and mulch had significant effect on number of nodules and nodule weight/plant in pea (Table 1). The CT recorded 9.2 and 5.2% higher number of nodule and nodule weight respectively over ZT. However, nodule parameters were similar to growth characters and higher number and weight were recorded with PSM (45.2 and 22.0%, respectively) and was close to MS (39.8 and 18.5%, respectively) followed by TG (31.7 and 14.8%, respectively). However, NM had the least nodule number and weight. This might be due to the fact that CT and PSM facilitated better root growth, which helped in uptake of phosphorus from deeper layer. Higher uptake of phosphorus enhanced the plant to produce nodules and better development leading to higher nodule weight in the present study similar to that of Kanaujia *et al*. (1997) who reported positive effect of mulches on phosphorus on pea.

Table 1. Growth and yield attributes of pea as influenced by tillage and mulches (pooled data of three years)

Treatment	Plant height (cm)	Branches/ plant	Dry weight (g/plant)	Nodules / plant	Nodule weight (mg/ plant)	Pods/ plant	Pod length (cm)	Seeds/pod
Tillage								
CT	74.15	4.62	10.61	16.18	115.75	22.83	5.83	5.67
ZT	66.51	3.93	9.58	14.82	110.00	18.25	5.68	5.58
CD (P=0.05)	1.95	0.61	0.45	0.25	4.08	3.63	0.14	NS
Mulch								
PSM	75.60	4.85	11.60	17.42	121.00	25.83	5.90	5.90
MS	73.70	4.50	10.95	16.77	117.50	22.50	5.82	5.67
TG	70.57	4.22	10.20	15.80	113.83	19.83	5.72	5.63
NM	61.45	3.53	7.63	12.00	99.17	14.00	5.58	5.30
CD (P=0.05)	4.14	0.49	0.73	1.20	6.51	4.87	NS	0.48

CT: conventional tillage; ZT: zero tillage; PSM: paddy straw mulch; MS: maize stubbles; TG: thatch grass (*Imperata cylendrica)*; NM: no mulch

Table 2. Yield and root characters of pea as influenced by tillage and mulches (pooled data of three years)

Treatment	Green pod yield (t/ha)	Seed yield (t/ha)	Stover yield (t/ha)	Harvest index	Maximum root length (cm)	Root numbers/plant	Root dry weight (g/plant)	Root volume (cc/plant)	Root density (mg/cc)
Tillage									
CT	2.60	1.43	3.27	0.30	25.53	12.74	2.61	16.68	15.72
ZT	2.34	1.17	3.03	0.28	19.50	16.18	2.18	13.38	16.43
CD (P=0.05)	0.07	0.10	0.06	0.01	1.17	1.15	0.32	0.78	NS
Mulch									
PSM	2.75	1.45	3.42	0.30	21.38	15.43	1.98	13.57	14.83
MS	2.66	1.38	3.30	0.30	22.63	14.15	2.22	13.57	16.53
TG	2.45	1.29	3.14	0.29	18.37	16.20	2.43	14.97	16.54
NM	2.02	1.08	2.74	0.28	27.68	12.07	2.95	18.02	16.40
CD (P=0.05)	0.08	0.06	0.07	0.01	1.67	1.40	0.36	2.34	NS

Yield attributes

Among yield attributes recorded, pods/plant was 25.1 per cent higher with CT over ZT (Table 1). However, pod length and seeds/pod was statistically comparable. More pods/plant was due to the higher accumulation of photosynthates which enhanced the plant to produce more number of flower buds and finally led to bearing more pods. Nevertheless, pod length and seeds/pod are more related to genetic traits. Similar results were reported by Tomar *et al*. (2006) and Saha *et al*. (2010) in maize, who concluded that plant height, number of green leaves, dry matter and numbers of grains/ear were reduced with ZT as compared with CT.

Table 3. Interactions of mulches and tillage on yield and root characters of pea as influenced by tillage and mulches (pooled data of three years)

Treatment	Green pod yield (t/ha)		Seed yield (t/ha)		Stover yield (t/ha)		Harvest index		Maximum root length (cm)		Root dry weight (g/plant)		Root volume (cc/plant)	
Mulch	CT	ZT	CT	ZT	CT	ZT	CT	ZT	CT	ZT	CT	ZT	CT	ZT
PSM	2.86	2.65	1.56	1.33	3.51	3.33	0.31	0.29	24.43	18.33	2.17	1.80	15.00	12.13
MS	2.78	2.54	1.48	1.28	3.46	3.14	0.30	0.29	25.53	19.72	2.35	2.07	15.00	12.14
TG	2.64	2.25	1.43	1.15	3.28	3.01	0.30	0.27	20.10	16.66	2.63	2.23	16.77	13.17
NM	2.12	1.91	1.23	0.92	2.83	2.64	0.30	0.26	32.07	23.30	3.27	2.63	19.93	16.10
CD (P=0.05)	0.10		0.08		0.09		0.02		2.36		0.51		3.30	

Mulch followed the similar trend to tillage practice. Pod number/plant was 85.5, 60.7 and 41.6 per cent higher with PSM, MS and TG, respectively over NM. Similarly, pod length and seeds/pod were recorded higher with PSM however it was statistically not significant among mulches. But NM recorded the lowest values for yield attributes. It clearly depicts that application of mulches during post rainy season encourage the plants for excellent crop growth and led to higher yield characters as also reported by Sarkar *et al*. (2007) and Suresh Kumar *et al*. (2012).

Table 4. Soil moisture content (%) (60 DAS) at different soil depths as influenced by tillage and mulches (pooled data of three years)

Treatment	Soil depth (cm)		
	0-10	10-20	20-30
Tillage			
CT	13.03	14.75	15.70
NT	14.55	15.88	17.30
CD (P=0.05)	0.43	0.57	0.78
Mulch			
PSM	14.60	16.25	17.30
MS	13.80	15.50	16.85
TG	15.05	16.45	17.55
NM	11.70	13.05	14.30
CD (P=0.05)	1.05	1.24	1.87

Yield

Observations on green pod, seed and stover yield revealed that they were significantly influenced by tillage and mulches (Table 2). CT had 11.1, 7.8, 10.0 and 7.8% higher green pod, seed, stover yield and harvest index respectively over ZT. These might be due to more number of branches, dry matter, pods/plant and seeds/pod, which finally contributed to yield. Nemecek *et al*. (2008) concluded that CT could be associated with the reduced soil penetration resistance, reduced bulk density, increased soil moisture preservation, improved soil structure, enhanced root-soil contact and better weed growth suppression which favourably affected root development, plant growth, plant population, resulting in increased yield. Among the mulches, PSM, MS and TG had 36.1, 31.7 and 21.3%, respectively higher green pod, 34.3, 27.8 and 19.4%, respectively seed yield and 24.8, 20.4 and 14.6% respectively stover yield over NM. Similarly, PSM had higher harvest index followed by MS and the lowest with NM. Higher yield with PSM and MS was due to increased dry matter accumulation in the early stage and optimized dry matter distribution at the later stages. It created the favourable soil moisture and temperature to stimulate crop growth (Ramakrishna *et al*., 2006). Interactions of tillage and mulch for yield of green pod, seed and stover and harvest index also had shown significant difference (Table 3).

Root characteristics

Root characters like root length, root numbers, root dry weight and root volume were significantly influenced by tillage and mulches (Table 2). CT had higher root length (30.9%), root dry weight (19.7%) and root volume (24.7%) than ZT. In contrary, root numbers was 27.0% lower with CT. However, root density was statistically not significant to tillage practices. Under ZT distinct hard and compact

layer was developed at the top, which consistently showed higher penetration resistance than CT. But, pulverized top layer in CT favoured deeper and easy penetration of roots. Pulverized top layer reduced the bulk density which led to better root growth (Saha *et al*., 2010). Among the mulches, the maximum root length for PSM, MS and TG was 29.5, 22.3 and 50.7%, respectively and root numbers/plant was 27.8, 17.2 and 34.25, respectively higher over NM. But root volume/plant was 32.8, 32.8 and 20.5% respectively lower over NM. But, root density/plant did not show any significant difference with mulches. The use of mulches improved the bulk density and reduced the compaction of soil which in turn enhanced the aeration and microbial activities in the soil. It resulted in increased root penetration and cumulative feeding and thus increased plant growth and yield. The results obtained were in line with the finding of Mbah *et al*. (2010). The interaction of variables also exhibited significant differences on root length, root dry weight and root volume (Table 3).

Soil moisture content

Soil moisture content at 0-10, 10-20 and 20-30 cm soil depths was 11.7, 7.6 and 10.2% respectively higher with ZT over CT (Table 4). Conventional Tillage had more exposed area which led to more evapo-transpirative demand of crop, whereas due to minimum disturbances and crop residues present on surface, Zero Tillage had least exposed area (Sarkar *et al.*, 2007). Among the mulches, TG had higher soil moisture content 28.6, 26.1 and 22.7%, respectively followed by PSM (24.8, 24.5 and 21.0%, respectively) in different depths. However, lower soil moisture content was recorded with NM. This might be due to no protection from direct exposure to environment as indicated by Sarkar *et al.* (2007).

From the study, it could be concluded that pea could be cultivated after harvest of rice rather than keeping land fallow. Depending on the availability of resources and condition either Zero tillage or Conventional tillage along with paddy straw mulch could be practiced during post rainy season for pea cultivation to get additional yield and restore the soil fertility.

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