Indian J. Dryland Agric. Res. & Dev. 2015 30(2) : 58-61 DOI 10.5958/2231-6701.2015.00026.3

Effect of Preparatory Tillage and Mulch on Productivity of Rainfed Pigeonpea [*Cajanus cajan* (L.) Millsp.]

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ABSTRACT: An experiment was carried out at Junagadh (Gujarat) during *kharif* seasons of 2011 and 2012 to assess the growth and yield of pigeonpea to preparatory tillage (conventional tillage, shallow tillage, row subsoiling and deep tillage) and mulching (control, soil mulch, wheat straw, groundnut shell and weed mulch). The results revealed that deep tillage up to 30 cm soil depth by tractor drawn disc plough and row subsoiling up to 30 cm by tractor drawn two-tyned subsoiler significantly improved growth and yield attributes *viz*., plant height, plant spread, number of branches/plant, number of pods/plant, number of grains/pod, grain weight/plant and 100-grain weight and thereby increased grain yield (1376 kg/ha) and stalk yield (3207 kg/ha) with higher B:C ratio (2.10) and increased soil moisture content over conventional tillage (cross cultivation followed by blade harrowing and planking). The mulching with wheat straw @ 5 t/ha enhanced growth and yield parameters *viz*. plant height, plant spread, number of branches/plant, number of pods/plant, number of grains/pod, grain weight/plant and 100-grain weight and ultimately increased grain yield (1387 kg/ha) and stalk yield (3212 kg/ha) with higher B:C ratio (1.83) and conserved more soil moisture over no mulch.

Key words: Pigeonpea, tillage, subsoiling, wheat straw, groundnut shell, weed mulch

Pulses is considered as an important part of food crops occupying unique position in agriculture. In the country like India where people are predominantly vegetarians, pulses is main source of protein and has vital importance in daily diet. Pigeonpea [*Cajanus cajan* (L.) Millsp] commonly known as redgram, Tur or Arhar is the fifth prominent legume crop in the world and second in India after chickpea. It is mainly grown in India, Africa, South East Asia and West Indies as one of the most important cash crops. Being leguminous plant, it plays an important role in improving the soil fertility and consequently the productivity of succeeding crops.

The major area in India remains under rainfed conditions, where pigeonpea cultivation is confined to varying types of soil ranging from vertisol, alfisol to sandy soils of different fertility levels. In Gujarat 60 to 70% of total area is under dry farming. Inadequate rainfall and its uneven distribution along with frequent droughts are the common features of this region leading to low and unstable yield of pigeonpea.

The Saurashtra region of Gujarat is highly influenced by the vagaries of monsoon, which result in low and unstable crop yields. The region faces twin problems of inadequate moisture availability and occurrence of mild to severe drought that result in partial or total failure of crop. The seasonal variation in rainfall is quite high where much of rainfall with high intensity causing heavy runoff and soil erosion and storing less moisture in the soil profile for plant growth. The most efficient and cheapest way of conserving soil moisture *in-situ* is to arrest the rain water. Tillage and mulches are the appropriate agronomic practices to conserve rain water and sustain crop production (Singh and Das, 1998).

Successful crop production depends upon the method and number of operations carried out for loosening the soil and maintaining proper tilth. It is established that tillage operations help in controlling weeds, pests and diseases as well as conserving the soil moisture through increased infiltration rate. Tillage operations also increase soil aeration which stimulate root penetration and proliferations thus, enabling the roots to draw water and nutrients from deeper soil layer, these ultimately increase crop productivity.

Besides tillage, mulches also help to reduce the evaporation from soil surface and transpiration through weeds by suppressing weed growth. Thus, mulches save water as well as check run off water on soil surface and increase the infiltration rate. This infiltration water serves as conserved soil moisture for rainfed crop (Itnal, 1998).

Keeping the above points in view, an experiment was conducted to ascertain appropriate tillage and mulch for increasing the productivity of pigeonpea under rainfed conditions.

Materials and Methods

A field experiment was undertaken at Instructional Farm, Department of Agronomy, Junagadh Agricultural University, Junagadh (Gujarat) during 2011 and 2012. The soil of the experimental plot was clayey in texture and slightly alkaline in reaction (pH 7.8 and EC 0.28 dS/m) as well as medium in available nitrogen (271 kg/ha), available phosphorus (24.4 kg/ha) and available potash (251 kg/ha). The trial comprising four preparatory tillage practices (CT: Conventional tillage, ST: Shallow tillage, RS: Row subsoiling and DT: Deep tillage) and fivemulching treatments (Control, SM: Soil mulch, WS: Wheat straw mulch, GS: Groundnut shell mulch and WM: Weed mulch) were laid out in strip plot design with four replications. The conventional tillage comprised cross cultivation followed by blade harrowing and planking. Shallow tillage was done up to 15 cm depth by bullock drawn plough. Row subsoiling was carried out up to 30 cm depth by tractor drawn two-tyned subsoiler and deep tillage was done up to 30 cm depth by tractor drawn disc plough. The improved variety 'Gujarat Tur-1' was sown at 90 cm row spacing by bullock drawn seed drill at the onset of monsoon during both the years. The seeds were treated with liquid *Rhizobium* culture @ 10 ml/kg seed before sowing. The fertilizer dose of 25-50 kg N-P_2O_5/ha in form of Diammonium Phosphate and Ammonium Sulphate was applied to the crop just before sowing.Thinning and gap filling were carried out at 10-12 DAS to maintain intra-row spacing of 20 cm. In case of soil mulch, shallow intercultivation operation was carried out with bullock drawn blade harrow at 20, 40 and 60 days after sowing (DAS). Wheat straw mulch (5 t/ha), groundnut shell mulch (5 t/ha) and weed mulch (5 t/ha) were spread uniformly in standing crop at 30 days after sowing by manual labour. Three hand weedings at 30, 60 and 90 DAS were carried out to control weeds.The recommended package of practices was adopted for raising the crop. The observations on growth and yield attributes, yield and quality were recorded at harvest. The protein content in grain was calculated by multiplying nitrogen content by a factor 6.25. Modified Kjeldahl method was adopted to find out nitrogen content. The soil moisture up to 30 cm soil depth was measured gravimetrically at 60 DAS, while bulk density was determined at harvest of the crop using core method.

Results and Discussion

Tillage

A perusal of data presented in Table 1 showed that tillage practices significantly influenced the growth parameters of pigeonpea *viz*., plant height, plant spread and number of branches/plant. Significantly the highest plant height (204 cm), plant spread (133 cm) and number of branches/plant (18.7) were observed under deep tillage (DT), however it remained statistically at par with row subsoiling (RS). While significantly the lowest values of these growth attributes registered under the conventional tillage (CT). This can be attributed to higher moisture availability to the crop owing to increase in infiltration of rain water in soil and water storage capacity and better aeration due to lower bulk density and porosity with deep tillage and subsoiling. These findings corroborated with the results of Vadi *et al.* (2006) and Idapuganti *et al.* (2007).

Table 1 also shows that deep tillage (DT) registered significantly the highest number of pods/plant (140), number of grains/pod (4.13), grain weight/plant (20.9 g) and 100-grain weight (11.7 g), which was statistically comparable to row subsoiling (RS). On the other hand, significantly the lowest values of these yield parameters were found under the conventional tillage (CT).Improvement in these yield attributes with deep tillage and subsoiling might have been on account of overall improvement in vegetative growth and nodulation, which favourably influenced the flowering and fruiting. These results are in agreement with those reported by Vadi *et al.* (2006) and Idapuganti *et al.* (2007).

Different tillage treatments manifested their significant effect on grain and stalk yields of pigeonpea (Table 1). Significantly the highest grain yield (1376 kg/ha) and stalk yield (3207 kg/ha) were produced under deep tillage (DT), however it remained statistically at par with row subsoiling (RS). The conventional tillage (CT) gave significantly the lowest grain (1191 kg/ha) and stalk (2671 kg/ha) yields. On an average of two years, deep tillage (DP) and row subsoiling (RS) increased grain yield by 15.5 and 8.6% and stalk yield by 20.1 and 13.8% over conventional tillage (CT). The deep tillage (DT) and row subsoiling (RS) also recorded higher B:C ratios compared to the conventional tillage (CT). The protein content in grain remained unaffected under various tillage treatments. Favourable rhizospheric condition created under deep tillage and row subsoiling might have enhanced moisture and nutrient availability to plants especially under dry spell, which might have enhanced growth and development of the crop and ultimately higher yield. These results could be supported by studies of Desai *et al.* (2000), Vadi *et al.* (2006) and Idapuganti *et al.* (2007).

The deep tillage (DT) was found efficient in moisture conservation by recording significantly the highest soil moisture content at 60 DAS (23.8%), followed by the row subsoiling (RS). The conventional tillage (CT) recorded the lowest soil moisture content (19.5%). However, different tillage practices did not manifest significant influence on bulk density of soil at harvest. The deep tillage and row subsoiling could have provided friable, soft seedbed and improved physical environment in the root zone resulting in higher infiltration of rainwater thereby improving the soil moisture status. While conventional tillage with lower soil moisture could have created higher vapour pressure gradient between atmosphere and crop canopy resulting in more evaporation loss of water. The results supported the findings of Mathukia and Khanpara (2009) in castor, and Gajera and Ahlawat (2002) and Vadi*et al.* (2005) in pigeonpea.

Mulch

Data furnished in Table 1 indicated that growth attributes of pigeonpea were varied under different mulch treatments. Significantly the highest plant height (202 cm), plant spread (132 cm) and number of branches/plant (19.3) recorded with the wheat straw mulch (WS) were statistically equivalent to groundnut shell mulch (GS). Significantly the lowest values of these growth attributes were observed under no mulch (control). This might be due to conserving more soil moisture by wheat straw and groundnut shell mulch, reducing the evaporation, maintaining optimum soil temperature, improving soil physical conditions and availability of more plant nutrients and increase in microorganism activity. These findings are in agreement with those of Gajera and Ahlawat (2002) and Vadi *et al.* (2006).

The yield attributes of pigeonpea *viz*., number of pods/plant, number of grains/pod, grain weight/plant and 100-grain weight recorded under various mulches were found to be

Table 1 : Growth, yield and quality of pigeonpea and soil properties under various tillage and mulch treatments (Pooled over 2 years)

Treatment	Plant height (cm)	Plant spread (cm)	Branches/ plant	Pods/ plant	Grains/ pod	Grain weight/ plant (g)	Test weight (g)	Grain yield (kg/ha)	Stalk yield (kg/ha)	B:C ratio	Protein content (%)	Soil moisture (%) #	Bulk density (g/ cm^3)*
Tillage													
CT	158	113	14.9	120	3.42	16.7	10.1	1191	2671	1.25	22.1	19.5	1.42
ST	171	120	16.0	129	3.65	18.1	10.6	1220	2802	1.45	22.3	20.5	1.39
RS	193	126	17.2	133	3.92	19.9	11.2	1293	3040	1.73	22.6	21.7	1.35
DT	204	133	18.7	140	4.13	20.9	11.7	1376	3207	2.10	22.8	23.8	1.32
SEm±	5	3	0.6	3	0.10	0.5	0.3	20	88	0.07	0.3	0.5	0.06
CD (P=0.05)	16	9	1.8	10	0.32	1.6	0.8	64	280	0.23	NS	1.6	NS
Mulch													
Control	161	114	14.0	113	3.45	16.6	10.1	1179	2665	1.39	22.5	19.7	1.47
SM	173	118	15.8	128	3.61	17.6	10.6	1205	2883	1.62	22.0	20.5	1.43
WS	202	132	19.3	142	4.13	21.2	11.8	1387	3212	1.83	23.0	23.4	1.28
GS	191	128	17.5	137	3.91	20.1	11.1	1328	3091	1.79	22.7	22.2	1.32
WM	181	123	16.9	132	3.80	19.0	10.9	1251	2799	1.57	22.1	21.1	1.35
SEm±	5	3	0.7	3	0.10	0.5	0.3	23	91	0.06	0.3	0.6	0.02
CD (P=0.05)	14	8	2.0	9	0.32	1.5	0.8	71	280	0.19	NS	1.8	0.06

CT=Conventional tillage, ST=Shallow tillage, RS=Row subsoiling, DT=Deep tillage, SM=Soil mulch, WS=Wheat straw, GS=Groundnut shell, WM=Weed mulch, # recorded at 60 days after sowing, * recorded at harvest significant (Table 1). Obviously, mulching with wheat straw (WS) registered significantly the highest number of pods/plant (142), number of grains/pod (4.13), grain weight/plant (21.2 g) and 100-grain weight (11.8 g), however it was statistically at par with groundnut shell mulch (GS). Significantly the lowest values of these yield aatributes were recorded with no mulch (control). The enhanced yield attributes with mulching can be attributed to optimum soil temperature, increased microbial activity, reduced evaporation, conserving more soil moisture and uptake of more nutrients that in turn resulted in better plant growth, photosynthetic activity and partitioning of assimilates. These results are in conformity with those reported by Gajera and Ahlawat (2002) and Vadi *et al.* (2006).

Moreover, the wheat straw mulch (WS) produced significantly the highest grain yield (1387 kg/ha) and stalk yield (3212 kg/ha), however it was found statistically comparable to the groundnut shell mulch (GS). Significantly the lowest grain yield (1179 kg/ha) and stalk yield (2665 kg/ha) were recorded under no mulch (control). On an average of two years, the wheat straw mulch (WS) and groundnut shell mulch (GS) increased grain yield to the tune of 17.6 and 12.6% and stalk yield to the extent of 20.5 and 16.0% over no mulch (control). Higher benefit-cost ratios (BCR) of wheat straw mulch (WS) and groundnut shell mulch (GS) over no mulch (control) ensures higher economic returns of the farmer over the latter. Mulching treatments did not exert their significant influence on grain protein content. The increased grain and stalk yield with wheat straw and groundnut shell mulch could be attributed to the favourable soil hydrothermal regime, increased microbial activity and availability of nutrients leading to favourable rhizosphere which resulted in better crop growth. Further, the favourable effect of soil environment with optimum temperature leads to better physiological process resulting in increased photosynthetic activity, optimum source and sink relationship and better translocation of assimilates which results in optimum pod development thereby favoured yield attributes and finally yield. The results are in conformity with the findings of Gajera and Ahlawat (2002) and Vadi *et al.* (2006).

The wheat straw mulch (WS) and groundnut shell mulch (GS), being at par with each other, significantly increased soil moisture content at 60 DAS (23.4 and 22.2%, respectively) and reduced bulk density at harvest (1.28 and 1.32 g/cm^3, respectively) over no mulch (control). The higher soil moisture content with mulches could be attributed to increased downward movement of rainwater, reduced weed growth and evaporation. Similar results were also reported by Selvi*et al.* (2009) and Mondal *et al.*(2013). The lower bulk density with wheat straw and groundnut shell mulch might be due to increase in soil aeration and soil porosity.

The interaction between tillage practices and mulches remained non-significant for all the characters under study.

Conclusions

From this study, it was inferred that deep tillage and row subsoiling up to 30 cm improved growth and yield attributes and there by increased grain and stalk yields with higher B:C ratios and increased soil moisture content over conventional tillage (cross cultivation followed by blade harrowing and planking). The mulching with wheat straw and groundnut shell @ 5 t/ha each enhanced growth and yield parameters and ultimately increased grain and stalk yields with higher B:C ratios and conserved more soil moisture over no mulch.

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Received: December 2014; Accepted: August 2015