International Journal of Pharmacognosy and Pharmaceutical Sciences

ISSN Print: 2706-7009
ISSN Online: 2706-7017
IJPPS 2019; 1(2): 21-25
www.pharmacognosyjournal.net
Received: 21-10-2019
Accepted: 09-11-2019

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Study of moisture conservations as influenced by tillage and land configuration practices on soybean (*Glycine max* (L.) Merill.) Under rain fed condition

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DOI: https://dx.doi.org/10.33545/27067009.2019.v1.i2a.56

Abstract
An agronomic investigation "Effect of tillage and land configuration practices on growth and yield of rainfed soybean (*Glycine max* (L.) Merrill.)" was carried out at Experimental Farm, Department of Agronomy, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during *Kharif* 2016. The experiment was conducted under dryland condition which consisted of three treatments of tillage practices as main plots and four treatments of land configurations as sub plots constituting twelve treatment combinations which were replicated thrice in split plot design. Three tillage practices *i.e.* T_1 (conventional tillage), T_2 (rotary tillage) and T_3 (sub soiling tillage) were tested with four land configurations i.e. L_1 (broad bed furrow), L_2 (flatbed), L_3 (ridges & furrow) and L_4 (opening of furrow) in the investigation. In this study, the moisture storage was induced by tillage practices using sub soiling tillage. Results of the study revealed that, sloughing + cultivator + harrowing + subsoil recorded highest moisture storage of soil. From the results of the study it can be revealed that, the moisture content at various growth stages were recorded *viz*. at sowing, at 15, 30, 45, 60, 75, 90 and at harvest. At sowing there was almost uniform moisture content in all the treatments. At 15 DAS measured moisture content was higher in sub soiling tillage practice and it 37.02% for 30-45 cm depth, 36.02% for 15-30 cm depth and 34.39% for 0-15 cm depth which was found to be higher than rest of the tillage practices. At 90 DAS measured moisture content was higher in sub soiling tillage practice and it 38.00% for 30-45 cm depth, 37.85% for 15-30 cm depth and 36.00% for 0-15cm depth which was found to be higher than rest of the tillage practices *i.e.* rotary tillage and conventional tillage. At harvest measured moisture content was higher in sub soiling tillage practice and it 27.37% for 30-45cm depth, 26.08% for 15-30cm depth and 25.33% for 0-15cm depth which was found to be higher than rest of the tillage practices. Among land configurations, at sowing there was almost uniform moisture content in all the treatments. At 15 DAS measured moisture content was higher in broad bed furrow and it 32.10% for 30-45cm depth, 31.25% for 15-30cm depth and 30.08% for 0-15cm depth which was found to be higher than rest of the land configuration. At 90 DAS measured moisture content was higher in bed furrow and it 36.85% for 30-45cm depth, 35.88% for 15-30cm depth and 35.20% for 0-15cm depth which was found to be higher than rest of the land configuration *i.e.* ridges and furrow, flat bed and opening of furrow. At harvest moisture content was higher in broad bed furrow and it 28.61% for 30-45 cm depth, 27.97% for 15-30cm depth and 26.40% for 0-15cm depth which was found to be higher than rest of the land configuration *i.e*. ridges and furrow, flat bed and opening of furrow.

Keywords: Tillage practices, land configuration, moisture conservations, yield attributes and soybean

Introduction
Soybean [*Glycine max* L. Merill.] is one of the important oilseed as well as leguminous crop. Due to its high nutritive value soybean cultivation has taken great strides during the recent years. It is cheapest and richest source of high quality protein. Bed planting is a technique of crop establishment, which is found promising during *kharif* season (Van Cooten and Borrell, 1999) [12]. Rain fed agriculture occupies 60% net sown area of the country, contributing 44% of total agriculture production with an average productivity of one tone/ha and supporting 40% of the total production. The productivity of the dry land crops is very low because of low and erratic rainfall and low adoption of improved rain fed agro-technologies. The loss in yield can be avoided or minimized if good amount water is stored in the soil during rainy days and utilized by the crop during moisture stress or dry spell. Whereas, at the same time there should be provision for drainage of excess rain water.

Studies on soil management for increasing crop production revealed that, use of various tillage methods and modification of land configurations such as broad bed furrow, ridges and furrow for soybean in vertisols were superior over flat bed and recommended in watershed development for moisture conservation as well as for safe removal of excess rain water. So adoption of agronomic practices like sub soiling tillage and broad bed furrow are found better in conserving rain water and improving oil moisture for further use for crop improvement. In this context the said experiment was conducted with objective to find out effect of tillage practices and land configuration on soil moisture conservation.

Materials and Methods

An experiment was conducted at field plot number A-7 at PG Research Farm, Department of Agronomy, Vasantrao Naik Marathwada Krishi Vidhyapeeth, Parbhani during *kharif* 2016. The soil of the experimental plot was clayey in texture with 0.58% organic carbon and 195.50kg/ha, 12.90 kg/ha, 470.70kg/ha available N, P and K respectively. Parbhani is grouped under assured rainfall zone. The total rainfall received during the crop growth period was 1126.7 mm (June to Oct. 2016) with over 51 rainy days. The experiment was laid dawn in split plot design with three replications with gross plot size 6.0 m × 10.0 m and net plot size 4.5m × 8.0m. There were twelve treatment combinations consisting of main plot treatments of tillage practices as sowing on conventional tillage (T_1), rotary tillage (T_2) and sub soiling tillage (T_3) and sub plot treatment of land configurations *viz*, broad bed furrow (L_1), flat bed (L_2), ridges and furrow (L_3) and opening of furrow (L_4).

The moisture percentage was worked out with gravimetric method as follows: Formula:

$$\text{Moisture percent} = \frac{W_1 - W_2}{W_2} \times 100$$

Where, W_1 - Weight of 50 gm wet soil sample

W_2 - Weight of 50 gm oven dried soil sample.

To determine the soil moisture content in mm gravimetric method was used. The soil moisture percentage is converted to mm by volumetric basis the formula suggested by Ramkrishna Rao *et al.* (1978) [9].

$$\text{Mm of water} = \frac{\text{Moisture percentage x B.D x Depth of soil}}{100}$$

Results and Discussion

Moisture content (%) in different tillage practices land configurations at different intervals

The moisture content in soil from 0-45 cm depth was significantly influenced due to various tillage practices and land configurations at all the stages of crop growth up to the harvest of crop (Table 1). Highest moisture content was observed at 90 DAS in the depth of 30-45cm (38.00%) followed by 75 DAS in the depth of 30-45cm (36.75%) and at 15 DAS in the depth of 30-45cm (37.02%) in sub soiling tillage treatment and it was found to be higher than the other treatments. While, among different land configurations, broad bed furrow (L_1), recorded highest moisture content at 90 DAS depth of 30-45cm (36.85%) followed by 75 DAS depth of 30-45cm (34.75%) and 15 DAS depth of 30-45cm (36.75%) over rest of the treatments. Nitant and Singh (1995) [6] in a short term experiment was observed that water contents were greater in deeper layers (0.15-0.30m and 0.30-0.45m) and deep tillage treatments and further noted that these differences were attributed to impeded drainage by compacted layers in shallow tillage treatments in contrast to the improved drainage due to loosening of the sub soil by the deep tillage.

Total moisture stored in various soil layers at depth of different intervals in different tillage practices and land configurations

Total moisture stored in various soil layers was significantly influenced due to various tillage practices and land configurations at all the stages of crop growth up to the harvest of crop. Total moisture stored in sub soiling tillage practice was higher than that of stored in conventional tillage and rotary tillage practices. Among different land configurations, total moisture stored in soil was highest under broad bed furrow, followed by ridges and furrow and opening of furrow. Whereas, it was lowest under flatbed method of planting.

Manian *et al.* (1999) [4] studied the influences of deep tillage on *in-situ* moisture conservation in dry farming and resulted that the deep tillage conserved moisture. They also showed drastic improvement in soil moisture storage under the deep tillage by chisel plough and Srivastava and Jangwad (1988) [11] working on water balance of watershed under different management practices revealed that the profile moisture accumulation in the flat bed system raised from 44 to 102 mm and that of BBF from 47 to 132 mm. They reported higher infiltration rate with BBF than flatbed which results in deep drainage.

Gajri *et al.* (1997) [2] assessed the differences in root growth and yield of wheat between conventional and deep tillage in a three-year field study conducted on alluvial sand in Northwest India. An optimum crop yield was obtained by sub soiling to 40-45 cm in which an increase of 2.3 t ha^{-1} was achieved. Deep tillage also decreased bulk density and soil strength in the tilled zone and increased the depth and density of rooting. Rajput *et al.* (1989) [7] studied performance of BBF and flat systems of farming in stabilizing the crop production in rain fed areas at Akola and obtained better results with BBF in terms of stored moisture (3% more) over flat system. BBF system helps in-situ moisture conservation and proper drainage which in turn results in maintaining high moisture content in soil profile during rainy and post rainy season and also helps in recharging the water content in the root zone.

Yield (kg ha^{-1})

The highly significant seed yield of soybean (3044 kg ha^{-1}) was recorded by sub soiling tillage practices (T_3) which was significantly superior over conventional tillage (T_1) and rotary tillage practices (T_2) treatments. While, considering land configurations, the treatment broad bed furrow (L_1) recorded significantly highest seed yield (2935 kg ha^{-1}) over flatbed (L_2), ridges & furrow (L_3) and opening of furrow (L_4) treatments. Among interaction effects the combinations (T_3L_1) recorded highest seed yield (3505 kg ha^{-1}) of soybean over rest of all the treatment combinations. The results correlate with the findings of Singh *et al.* (2011), Wesley *et al.* (1993), Nandurkar and Malvi (1998) [5] (Table 2).

The highest straw yield of soybean (4549 kg ha^{-1}) was recorded by sub soiling tillage (T_3) which was significantly superior over rest of treatments. In case of land configurations, the treatment broad bed furrow (L_1) recorded significantly more straw yield (4043kg ha^{-1}) over rest of the

treatments. Interaction effects (T_3L_1) recorded highest straw yield (5242kg ha^{-1}) of soybean over rest of the treatments (Table 2). This might be due to more favoured overall growth and yield attributing characters due to favourable seed bed, better aeration, scope for more space, light interception, benefit of more conserved moisture in furrows and its support at critical growth stages like flowering, pod initiation and pod development. This resulted in higher values of yield attributing characters and which in turn resulted in higher yield of soybean crop. These results correlate with the reports of Jaypaul (1996), Sharma *et al.* (2000) [10] and Raut *et al*. (2000) [8].

The effect of different tillage practices and land configuration treatments on biological yield was found to be significant. The highest biological yield of soybean (7593kg ha^{-1}) was recorded by sub soiling tillage practices (T_3) which was significantly superior over conventional tillage (T_1) and rotary tillage (T_2) (Table 2) treatments. Whereas in land configurations, the treatment broad bed furrow (L_1) recorded significantly more biological yield (6978kg ha^{-1}) over flatbed (L_2), ridges & furrow (L_3) and opening of furrow (L_4) treatments and it was found at par with ridges & furrow (L_3). Similar results were reported by Lomte *et al.* (2006) [3].

Economics of soybean as influenced by various treatments

The mean gross monetary returns of soybean was Rs.69676 ha^{-1}. Sub soiling tillage (T_3) recorded higher gross monetary returns (85241 Rs ha^{-1}) and it was found significantly higher over rest of the treatments. The rotary tillage (T_2) showed the significantly lowest gross monetary returns (57263 Rs ha^{-1}), (Table 2). In case of land configurations broad bed furrow (L_1) recorded the significantly higher gross monetary returns (82179 Rs. ha^{-1}) and it was found significantly superior over flatbed (L_2), ridges & furrow (L_3) and opening of furrow (L_4) treatments. Dikey *et al.* (2013) also revealed same results that although furrow opening after three rows was similar with others in terms of number of branches, pods and test weight, the above treatment showed significantly higher seed yield Venkateswarlu (1999) [13].

The interaction effects of significant gross monetary returns were recorded with combination of sub soiling tillage and broad bed furrow (T_3L_1) than rest of the treatment combinations and it was found to be at par with sub soiling and ridges & furrow (T_3L_3).

Sub soiling tillage (T_3) recorded significantly higher net monetary returns (Rs. 52429ha^{-1}) over rest of the treatments. The land configurations, broad bed furrow (L_1) recorded the highest net monetary returns (52099 Rs.ha^{-1}) and was found significantly superior over flatbed (L_2), ridges & furrow (L_3) and opening of furrow (L_4) treatments. The interaction effect of sub soiling tillage (T_3) and broad bed furrow (L_1) recorded highest net monetary returns (65660Rs.ha^{-1}) of soybean over rest of the treatment combinations. The mean B:C ratio of 2.29 was found. While considering land configurations, the treatment BBF was found significantly superior to other treatments in terms of seed yield, net returns and B:C ratio across locations and years. Similarly, Deshmukh *et al.* (2002) [1] reported that except Mauranipur (Uttar Pradesh), the higher crop yield and net returns were observed in Amreli, Jalgaon (Maharashtra) and Vridhachalam with BBF during 1997-2000.

The significantly higher rain water use efficiency were observed in tillage practices of sub soiling tillage (T_3) *i.e.* 3.87 kg/mm/ha. Hence, land configurations, broad bed furrow (L_1) *i.e.* 3.73kg/mm/ha recorded higher rain water use efficiency of crop.

Table 1: Moisture content (%) in different tillage practices and land configurations at different intervals.

Moisture content (%)								
Depth(cm)	**At sowing 28.6.2016**	**15 DAS 13.7.2016**	**30 DAS 28.7.2016**	**45 DAS 13.8.2016**	**60 DAS 28.8.2016**	**75 DAS 13.9.2016**	**90 DAS 28.9.2016**	**At harvest 15.10.2016**
Conventional tillage (T_1)								
0-15	29.78	32.65	32.92	23.29	31.86	32.80	33.11	22.62
15-30	30.32	33.75	33.15	23.53	32.41	33.25	34.27	23.65
30-45	31.72	35.68	33.60	23.44	32.63	33.90	35.34	24.34
Rotary tillage(T_2)								
0-15	28.74	29.38	29.80	21.86	28.64	30.21	31.71	21.36
15-30	29.57	30.41	29.95	22.91	29.56	31.76	32.75	22.15
30-45	30.54	31.95	31.25	23.33	30.98	32.49	33.47	22.51
Sub soiling tillage (T_3)								
0-15	30.21	34.39	34.68	25.65	33.27	35.25	36.00	25.33
15-30	31.23	36.02	35.98	26.04	33.61	36.42	37.85	26.08
30-45	32.68	37.02	36.90	26.70	34.15	36.75	38.00	27.37
Broad bed furrow (L_1)								
0-15	30.08	34.32	35.08	24.60	33.51	34.35	35.20	26.40
15-30	31.25	34.98	35.17	25.32	34.08	34.60	35.88	27.97
30-45	32.10	36.75	34.63	26.03	34.68	34.75	36.85	28.61
Flatbed (L_2)								
0-15	27.04	29.39	30.32	21.51	28.85	29.44	30.69	22.62
15-30	28.55	31.37	31.31	22.23	29.94	30.35	31.22	22.36
30-45	29.54	32.70	31.82	22.70	30.37	31.13	32.01	23.04
Ridge & furrow (L_3)								
0-15	29.03	33.80	33.67	24.26	32.71	33.51	34.11	25.66
15-30	30.53	34.19	34.11	24.51	33.44	34.18	34.92	26.16
30-45	31.80	35.89	34.16	25.01	33.70	34.44	35.83	27.00
Opening of furrow (L_4)								
0-15	28.75	31.38	32.13	23.21	31.62	31.99	32.49	23.80
15-30	29.73	32.72	31.74	23.25	31.66	32.28	33.72	24.31
30-45	30.68	34.59	32.78	23.12	31.94	33.24	34.54	25.00

Table 2: Total moisture stored in various soil layers soil depth at different intervals in various tillage practices and land configurations.

Total moisture stored in (mm)								
Depth (cm) 45cm	**At sowing 28.6.2016**	**15 DAS 13.7.2016**	**30 DAS 28.7.2016**	**45 DAS 13.8.2016**	**60 DAS 28.8.2016**	**75 DAS 13.9.2016**	**90 DAS 28.9.2016**	**At harvest 15.10.2016**
Conventional tillage (T_1)								
Moisture stored in mm	179.04	199.04	194.35	136.99	188.93	194.89	200.29	137.67
moisture stored Mm/m depth of soil	397.86	442.31	431.88	304.42	419.84	433.08	445.08	305.93
Rotary tillage (T_2)								
Moisture stored in mm	173.25	178.88	179.39	132.78	173.89	184.18	190.95	128.73
moisture stored Mm/m depth of soil	385.00	397.51	398.64	295.06	386.42	409.28	424.33	286.06
Sub soiling tillage (T_3)								
Moisture stored in mm	183.51	209.47	209.73	157.84	201.99	216.40	223.10	173.61
moisture stored Mm/m depth of soil	407.80	465.48	466.06	349.64	447.75	479.77	494.66	381.35
Broad bed furrow (L_1)								
Moisture stored in mm	182.17	206.79	204.50	153.09	204.41	207.21	217.40	181.80
moisture stored Mm/m depth of soil	404.82	459.53	454.44	336.08	450.13	457.35	450.00	389.55
Flatbed (L_2)								
Moisture stored in mm	165.99	182.24	182.21	129.54	173.75	177.28	183.12	153.69
moisture stored Mm/m depth of soil	368.86	404.97	404.93	287.86	386.11	393.95	406.93	341.53
Ridges & furrow (L_3)								
Moisture stored in mm	178.14	202.56	198.77	143.85	194.69	199.14	204.46	143.06
moisture stored Mm/m depth of soil	395.86	450.13	441.71	319.66	432.64	442.53	454.35	317.91
Opening of furrow (L_4)								
Moisture stored in mm	173.85	192.44	188.46	135.66	185.66	190.13	196.45	135.5
moisture stored Mm/m depth of soil	386.33	427.64	418.80	301.46	412.57	422.51	436.55	301.2

Table 3: Yield attributes influenced by various treatments.

Treatments	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)	Gross monetary return (Rs. ha^{-1})	Net monetary returns (Rs. ha^{-1})	Cost of cultivation (Rs. ha^{-1})	B:C Ratio	RWUE Kg/mm/ha
Tillage practices									
T_1- Conventional tillage	2385.10	3528.5	5913.80	40.33	66729	36867	29861	2.23	3.03
T_2-Rotary tillage	2037.80	3074.5	5111.20	39.85	57059	28595	28463	2.00	2.59
T_3-Sub soiling tillage	3044.30	4549.4	7593.80	40.08	85241	52429	32811	2.59	3.87
S.E. m ±	129.94	141.92	184.91	-	2650	1155	-	-	-
C.D. at 5 %	389.82	557.27	726.06	-	7862	3420	-	-	-
Land Configurations									
L_1 -Broad Bed Furrow	2935.00	4043.20	6978.00	42.06	82179	52099	30080	2.73	3.73
L_2 -Flat Bed	2045.10	3215.10	5260.90	38.87	57263	27932	29330	1.95	2.60
L_3 -Ridges &Furrow	2586.20	3919.70	6505.00	39.75	72414	40583	31830	2.27	3.29
L_4 -Opening of Furrow	2390.00	3691.90	6084.30	39.28	66919	36573	30274	2.21	3.04
S.E. m ±	109.88	113.07	163.84	.	4352	1238	-	-	-
C.D. at 5%	329.64	335.95	486.81	-	6351	3674	-	-	-
Interaction (T× L)									
S.E. m ±	162.51	195.84	283.78	-	4352	2145	-	-	-
C.D. at 5 %	487.53	581.89	843.18	-	12703	6363	-	-	-
General mean	2489.10	3717.50	6206.20	40.08	69676	39297	30379	2.29	3.16

Conclusion

Among the treatments, cultivation of soybean with sub soiling tillage (T_3) gave higher values for soil moisture conservations and in case of land configurations, broad bed furrow (L_1) gave higher values for soil moisture conservation.

Based on the results for the *Kharif* soybean crop sub soiling tillage may be followed (T_3) with broad bed furrow to achieve gave higher values for soil moisture conservation.

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