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Effect of tillage and land configuration practices on growth and yield of rainfed soybean (*Glycine max* (L.) Merill)

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Abstract
An agronomic investigation "Effect of tillage and land configuration practices on growth and yield of rainfed soybean" (*Glycine max* (L.) Merill)" was carried out at Experimental Farm, Department of Agronomy, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani M.S. (India) during Kharif 2016. The experiment was planned 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 (flat-bed), L_3 (ridges & furrow) and L_4 (opening of furrow) in the investigation.
The seed yield was found to be significantly higher in tillage practice of sub soiling tillage (T_3) 3044.30 kg ha^{-1} followed by conventional tillage (T_1) 2385.10 kg ha^{-1} and rotary tillage (T_2) 2037.80 kg ha^{-1}. Adoption of sub soiling tillage (T_3) gave higher gross monetary returns, net monetary returns and benefit & cost ratio. Whereas, among different land configurations, the seed yield also in broad bed furrow (L_1) 2935 kg ha^{-} were found to be significantly superior in respect of seed (kg ha^{-1}), straw (kg ha^{1}), biological yields^{-1} it was stood far ahead followed by ridges and furrow (L_3) 2586.20 kg ha^{-1}, opening of furrow (L_4) 2390 kg ha^{-1} and flatbed (L_2) 2045.10 kg ha^{-1}. Among various land configurations, broad bed furrow (L_1) recorded higher GMR, NMR, benefit & cost ratio.
Rain water use efficiency was found to be significantly higher in sub soiling tillage (T_3) and among land configurations, the broad bed furrow (L_1) recorded higher rain water use efficiency. The interaction effects between tillage practices and land configurations significantly influenced the growth and yield of soybean and sub soiling tillage (T_3) and broad bed furrow (L_1) combination recorded significantly higher soybean seed yield, GMR, NMR, and RWUE than rest of the treatment combinations. Thus to achieve higher soybean yield and higher NMR with maximum RWUE, soybean crop may be planted on sub soiling tillage and broad bed furrow (T_3 L_1).

Keywords: Tillage practices, land configurations, growth attributes, yield attributes, economics and soybean

Introduction
In India, soybean is grown over an area of 9.95 m ha with production of 102.3 lakh tonnes and productivity of 1230 kg per ha, contributing 41 per cent and 35 per cent to the total oilseed and edible oil production of the country. Rainfed agriculture occupies 60% net sown area of the country, contributing 44% of total agriculture production with an average productivity of one tonne/ha and supporting 40% of the total production. Over 87% of coarse cereals and pulses, 55% of upland rice, 70% of oilseeds and 65% of cotton are cultivated under rainfed agriculture (Nagaraj, 2013) [10]. Soybean is second most important crop of Maharashtra state followed by cotton in terms of acerage. However, 85% area of Maharashtra is under dryl and agriculture and inspite of good average rainfall. Crops failures are common due to uncertain behavior of monsoon. Among all legumes soybean is most sensitive to soil moisture stress condition.
Vagaries of monsoon and prolonged dry spells affect crop growth and yield and significantly in Marathwada region of Maharashtra. Even under normal rainfall situation crop failures are occurring due to moisture stress due to occurance of dry spells occurred particularly during critical crop growth stages. Hence, it is necessary to exploit the technologies for in-situ moisture conservation like tillage, land configurations, mulching etc.
Tillage is mechanical manipulation of soil to provide favorable conditions for crop growth which leads to nurturing of crops. It contributes materially in obtaining good tilth condition and even in moisture conservation. A subsoiler or flat lifter is a tractor mounted implement used to loosen and break up soil at depths below the level of a traditional ploughing, disk harrowing or rototiller of soil and helps in moisture conservation, tillage practices and land configurations.

Hence the said experiment was planned Different land configurations were made using tractor mounted implement *i.e.* flat bed, broad bed furrow and ridges and furrow.

Materials and Methods

The experiment was laid out in field plot number A-7 at PG Research Farm of Agronomy Department, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during *kharif* season of 2016 in well drained and medium deep black cotton soil. 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 present experiment was laid out by using Split plot design with three replications. The treatments were consisting of three tillage methods as main plot treatments and four land configurations as sub plot treatments.

Results and Discussion

Growth attributes

Number of pods plant$^{-1.}$

The significantly higher number of pods plant$^{-1.}$ Were observed in tillage practice of sub soiling tillage (T_3). Hence, land configurations, broad bed furrow (L_1) recorded significantly higher number of pods plant$^{-1.}$ at almost all growth stages (Table 1).Timely moisture availability led to higher growth of plant and finally gave rise to higher pod filling and increase in number of pods plant^{-1} due to proper growth of crop, which might have resulted in greater translocation of food material to the reproductive part, which also reflected towards superiority in yield attributing characters. The increased number of branches and more reproductive growth and conversion of flowers in pods with the support of more conserved soil moisture at peak period of pod initiation might have resulted in increased number of pods per plant. Similar results were observed by Dikey (2013) [3] and Desai, (1989) [1].

The interaction effects of tillage practices and land configurations in respect of the number of pods plant^{-1} was found to be significant at 75 DAS. Interaction effects between sub soiling tillage (T_3) and broad bed furrow (L_1) recorded higher number of pods plant^{-1} over rest of the treatment combinations at 75 DAS.

Dry matter accumulation plant^{-1} (g)

The significantly higher dry matter accumulation plant^{-1} were observed tillage practices of practice of sub soiling tillage (T_3). Hence, land configurations, broad bed furrow (L_1) recorded significantly higher dry matter accumulation plant^{-1} at almost all the stages of crop growth. (Table 1). This is due to luxurious growth and higher growth attributes recorded in BBF than rest of the land configurations and thus overall growth reflected in higher dry matter in BBF planted crop. Similar results were observed by Lomte (2006) [8] and Zhaojiuzhou *et al.* (1995) [19]. While combination of both gives (T_3L_1) recorded significantly highest total dry matter plant^{-1} of soybean over rest of the treatment combinations.

Number of nodules plant^{-1}

The significantly higher number of nodules plant^{-1} were observed tillage practices of practice of sub soiling tillage (T_3). Hence, land configurations, broad bed furrow (L_1) recorded significantly higher number of nodules plant^{-1}at almost all the stages of crop growth. (Table 1). The overall better growth and development with the support of conserved soil moisture might have reflected in higher seed weight plant^{-1}. The similar results were reported by Dikey *et al.* (2013) [3] and Ibrahim and Miller (1989) [4]. Interaction effects of sub soiling tillage and broad bed furrow (T_3L_1) recorded highest total number of nodules plant^{-1} of soybean over rest of the treatment combinations (Table 1). Similar results were observed by Merill *et al.* (1996) [9].

Yield attributes

The mean pods weight plant^{-1} (g) was significantly influenced by all the tillage practices and land configurations. Sub soiling tillage (T_3) recorded significantly highest pod weight plant^{-1} (12.00 g) than conventional tillage (T_1) and rotary tillage (T_2) treatments. In case of land configurations, broad bed furrow (L_1) recorded highest pod weight plant^{-1} (13.79g) and found significantly superior over the ridges & furrow (L_3), opening of furrow (L_4) and flatbed (L_2) (Table 2) treatment. reported similar results of Parameswaram *et al*. (1987) The treatment combination of sub soiling tillage and broad bed furrow (T_3L_1) recorded significantly highest pod weight plant^{-1} of soybean (16.18 g) over rest of the treatment combinations.

The data presented in Table 2 revealed that sub soiling tillage (T_3) recorded significantly higher weight of seeds plant^{-1} (8.35 g) than conventional tillage (T_1) and rotary tillage (T_2) methods of tillage practices. Among various land configurations, the highest weight of seeds plant^{-1} (9.90 g) was recorded in broad bed furrow (L_1) and it was found to be significantly superior over rest of treatments. The combination of sub soiling tillage and broad bed furrow (T_3L_1) recorded significantly highest weight of seeds plant^{-1} of soybean (11.20 g) than the rest of all the treatment combinations however, it was found at par with (T_3L_3) treatment combinations. Similar results were reported by Wesley *et al*. (1993) [18].

The 100 seed weight (g) was also influenced significantly by different tillage practices. Sub soiling tillage (T_3) recorded significantly highest 100 seed weight (10.04g) over the rest of the tillage practices. The land configurations, broad bed furrow (L_1) recorded significantly higher 100 seed weight (10.23 g) over the flat bed (L_2), ridges & furrow (L_3) and opening of furrow (L_4), however, it was found at par with ridges & furrow (L_3) treatment (Table 2). The combination of sub soiling tillage (T_3) and broad bed furrow (L_1) recorded highest 100 seed weight of soybean (10.76 g) than the rest of the treatment combinations. Whereas, it was at par with the combinations of T_1L_1, T_1L_3 and T_3L_3 treatments. The higher growth attributes followed by more synthesis and translocation of food material to the sink might have resulted in bold seed size and thus more weight of pods plant^{-1}. The effect of land configurations on yield attributes are in line with the reports of Talwar *et al.*, (2002) [15] and Lomte (2006) [8].

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) [14], Wesley *et al*. (1993) [18], Nandurkar and Malvi (1998) [11] and Tumbare and Bhoite (2002) [16] (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 (5242 kg 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) [7], Jain *et al*. (2000) [5], Sharma *et al.* (2000) [13] and Raut *et al*. (2000) [6].

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) [8].

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 Rsha^{-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) [3] 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) [17].

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) (Table 2).

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. (Table 2) 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) [2] 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.* 3.73 kg/mm/ha recorded higher rain water use efficiency of crop.

Conclusion

In tillage practices, cultivation of soybean with sub soiling tillage (T_3) gave higher values of growth attributes, yield attributes, seed yield, GMR, NMR and RWUE. In case of land configurations, broad bed furrow (L_1) gave higher values of growth attributes, yield attributes, seed yield and GMR, NMR and RWUE. Based on the results for the *Kharif* soybean crop sub soiling tillage may be followed (T_3) with broad bed furrow to achieve higher yield, GMR, NMR and rain water use efficiency.

Table 1: Growth attributes influenced by various treatments

Treatments	Number of pods plant^{-1} (DAS)				Dry matter accumulation plant^{-1}in gm(DAS)						Number of nodules plant^{-1}(DAS)				
	60	75	90	At harvest	30	45	60	75	90	At harvest	45	60	75	90	At harvest
Tillage practices															
T_1 –Conventional tillage	30.90	33.95	35.18	36.41	2.09	5.12	10.36	16.03	18.50	18.77	16.33	20.41	27.16	12.50	10.00
T_2 -Rotary Tillage	26.63	28.48	31.13	31.65	1.61	4.88	8.43	13.19	17.83	18.04	14.16	18.16	25.08	10.16	8.16
T_3- Sub soiling tillage	33.45	42.38	41.60	44.01	2.54	6.10	12.31	18.97	19.23	19.65	17.83	21.91	28.66	14.33	11.58
S.E. m±	0.49	0.88	0.55	0.46	0.17	0.19	0.21	0.16	0.19	0.27	0.43	0.42	0.45	0.55	0.55
C.D. at 5%	1.93	3.47	2.16	1.84	0.69	0.57	0.63	0.63	0.57	0.80	1.72	1.65	1.78	2.18	2.18
Land Configurations															
L_1 -Broad Bed Furrow	34.53	39.91	41.51	43.75	2.46	6.01	11.38	17.72	19.71	20.22	18.55	22.66	29.66	14.77	12.11
L_2 -Flat Bed	24.73	29.64	30.48	31.06	1.75	4.77	9.58	14.69	17.32	17.51	13.55	17.55	23.77	10.00	8.00
L_3 -Ridges & Furrow	33.22	36.80	36.84	40.62	2.22	5.78	10.56	16.51	19.05	19.41	17.00	21.11	28.11	13.00	10.33
L_4 -Opening of Furrow	28.82	33.40	34.46	34.57	1.90	4.92	9.93	15.33	18.06	18.13	15.33	19.33	26.33	11.55	9.22
S.E. ±	0.76	0.31	0.82	1.32	0.16	0.18	0.26	0.20	0.15	0.15	0.17	0.24	0.33	0.22	0.22
C.D. at 5%	2.26	0.92	2.45	3.93	NS	0.54	0.78	0.59	0.44	0.46	0.52	0.73	1.00	0.65	0.65
Interaction (T× L)															
S.E. m ±	1.32	0.53	1.43	2.29	0.28	0.30	0.37	0.34	0.30	0.27	0.30	0.42	0.58	0.38	0.38
C.D. at 5%	NS	1.60	NS	NS	NS	0.91	1.11	1.03	0.89	0.80	0.91	1.27	1.74	1.14	1.14
General mean	30.32	34.93	35.97	37.36	2.08	5.37	10.36	16.06	18.53	18.82	16.11	20.16	26.97	12.33	9.91

Table 2: Yield attributes influenced by various treatments

Treatments	Weight of podplant^{-1} (g)	Weight of seeds plant^{-1} (g)	Seed index (g)	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	10.47	7.08	9.30	2385.10	3528.5	5913.80	40.33	66729	36867	29861	2.23	3.03
T_2-Rotary tillage	7.73	5.41	8.19	2037.80	3074.5	5111.20	39.85	57059	28595	28463	2.00	2.59
T_3-Sub soiling tillage	12.00	8.35	10.04	3044.30	4549.4	7593.80	40.08	85241	52429	32811	2.59	3.87
S.E. m ±	0.41	0.06	0.10	129.94	141.92	184.91	-	2650	1155	-	-	-
C.D. at 5%	1.23	0.20	0.31	389.82	557.27	726.06	-	7862	3420	-	-	-
Land Configurations												
L_1 -Broad Bed Furrow	13.79	9.9	10.23	2935.00	4043.20	6978.00	42.06	82179	52099	30080	2.73	3.73
L_2 -Flat Bed	6.11	3.83	8.16	2045.10	3215.10	5260.90	38.87	57263	27932	29330	1.95	2.60
L_3 -Ridges &Furrow	12.57	8.63	10.05	2586.20	3919.70	6505.00	39.75	72414	40583	31830	2.27	3.29
L_4 -Opening of Furrow	7.79	5.33	8.25	2390.00	3691.90	6084.30	39.28	66919	36573	30274	2.21	3.04
S.E. m ±	0.41	0.22	0.10	109.88	113.07	163.84	.	4352	1238	-	-	-
C.D. at 5%	1.24	0.66	0.32	329.64	335.95	486.81	-	6351	3674	-	-	-
Interaction (T× L)												
S.E. m ±	0.56	0.38	0.18	162.51	195.84	283.78	-	4352	2145	-	-	-
C.D. at 5%	1.68	1.15	0.56	487.53	581.89	843.18	-	12703	6363	-	-	-
General mean	10.07	6.94	9.17	2489.10	3717.50	6206.20	40.08	69676	39297	30379	2.29	3.16

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