Indian Journal of Agronomy **61** (4): 489–494 (December 2016)

Research Paper

Effect of land configuration and mulching on productivity and energy use in groundnut (*Arachis hypogaea*)

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Received : October 2016; Revised accepted : December 2016

ABSTRACT

A field experiment was conducted during the rainy (*kharif*) seasons of 2013–15 on acid lateritic soils of Konkan, to study the effect of land configuration and mulching on resource use efficiency and productivity of groundnut (*Arachis hypogaea* L.). The experiment consisted of 4 land configuration and 3 mulching treatments. The pooled results revealed that, groundnut pod yield was significantly influenced by various land configuration and mulching treatments and it was significantly highest under broad bed and furrow method of land configuration (80–20 cm) i.e. 2.48 t/ha over flat bed sowing, ridges and furrow method (50 cm) and raised bed and furrow (30 width with 30 cm furrow) method of sowing. However, use of transparent polythene (7 micron) film mulch resulted in significantly higher pod yield of 2.50 t/ha over paddy straw mulching (2.18 t/ha) and no mulching (control), i.e. 1.70 t/ha. The maximum field water-use efficiency was observed under broad bed and furrow method with transparent polythene mulch (1.77 kg/ha-mm) treatment. Economics of the treatments indicated that, groundnut sown on broad bed and furrow method topped in the rank for net returns (₹31,392/ha) with benefit: cost ratio of 1.41:1. However, transparent polythene mulch noticed higher net returns of ₹26,341/ha with benefit to cost ratio 1:1.32 followed by paddy straw mulching (₹17,597/ha with 1.23 : 1 benefit: cost ratio). Broad bed furrow method with polythene mulch treatment showed the highest field water-use efficiency of 1.77 kg/ha mm, highest energy balance (63629 MJ/ha) with higher energy-use efficiency (4.11) and energy productivity of 0.14 kg/MJ.

Key words : Energy indices, Field water use efficiency, Groundnut, Land configuration, Mulching

Groundnut is an important oil seed crop of India. India, China, Nigeria, Senegal, Sudan, Burma and the United States of America are the major groundnut-producing countries. However, out of the total area of 18.9 million ha and the total production of 17.8 million tonnes in the world, these countries account for about 69% of the area and 70% of the production. India occupies the first place, both in regard to the area and the production in the world. About 7.5 million ha are put under it annually and the production is about 6 million tonnes. (Madhusudhana, 2013)

The loose and well-aerated seedbed is very important for groundnut growing, as loose soil surface is useful for penetration of pegs and development of pods. Thus crop has potential for increase in the yield. However, the main obstacle in extension of groundnut cultivation is the lack of information on field layouts and water-management technology. Also, the presence of hard pan in soil profile impedes root growth and exploitation of water and nutrients. Moreover, broad bed furrow technique provides loose soil mass for development of pods besides, this furrows are useful both for irrigation and drainage of excess water, as groundnut is more sensitive to water fluctuations and more or less at critical groundnut stages adversely affect the yield. Broad bed and furrow (BBF) configuration maintains soil loose and porous with due care to make it congenial for better storage of rainwater and extensive root-system which result better water and nutrient uptake by crop (Vaghasia *et al*. 2007). Various experiments conducted at International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) showed that increasing yield of groundnut can be obtained by growing it on broad bed furrow (ICRISAT, 1987). Whereas, Nalawade and More (1993) reported significant response of broad bed furrow technique, resulting in higher pod yield of groundnut.

The groundnut productivity has been improved by extensive use of polythene film for mulching under improved cultural practice. Various materials like straw, hay,

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trashes, dry leaves etc. have been used for long back as natural mulch to conserve soil moisture, arrest weed growth and improve in soil physical properties. However, in India, use of biodegradable plastic film as mulch in agricultural field is still in a conceptual stage. Capitalizing the biodegradable polythene film mulch technology is for revolutionizing groundnut yield. Therefore, the present investigation was undertaken to evaluate the impact of different land configuration and mulching on rainy (*kharif*) season groundnut under acid lateritic soils of Konkan.

MATERIALS AND METHODS

The present investigation was conducted at Agricultural Research Station, Dr. B.S. Konkan Krishi Vidyapeeth, Shirgaon, Dist. Ratnagiri, Maharashtra during the rainy (*kharif*) seasons from 2013 to 2015 with groundnut cultivar 'Trombay Konkan Groundnut-Bold' (TG 19A). The experiment was laid out in split-plot design, replicated three times. The main plot treatment consisted of 4 land configurations, viz. conventional method, broad bed and furrow (80–20 cm), ridges and furrows (50 cm) and raised bed and furrow (30–30 cm). However, subplot treatments consisted of 3 mulching treatments, viz. control, paddy straw mulch and polythene mulch. The soil was sandy loam and slightly acidic in reaction (*p*H 6.1), low in available nitrogen (276.8 kg/ha), phosphorus (10.05 kg/ha) and high in available potassium (326.8 kg/ha). The different land configurations, viz. broad bed furrow, were opened with help of plough having 80 cm top bed width and 20 cm furrow with 4 rows on each bed, while ridges and furrows were opened at every 50 cm distance in such a way that, the distance between 2 tops of ridges was 50 cm . Two rows of groundnut was planted on each ridge. The raised bed and furrow has 30 cm top width and 30 cm furrow (30 cm top width and 30 cm bottom width, i.e. furrow) and 2 rows were planted on each raised bed and furrow. The white transparent 7 micron polythene mulch and organic mulch, i.e. paddy straw, was used as mulching material and varied accordingly to treatments. The recommended dose of fertilizers, i.e. 25, 50 and 00 N, P and K kg/ha was used for all the treatments and pest and disease-control measures were followed as per need of crop. The rainfall received during the crop growth periods of groundnut during *kharif* (August 2013–December 2013, June 2014–October 2014 and June 2015–October 2015 were 941.3 mm, 2,217.6 mm and 2,235.1 mm respectively. No supplementary irrigation was provided to groundnut crop. The different inputs and output and their prices and energy equivalents used in groundnut production are presented in Table 4. Energy-use efficiency, energy specific and energy productivity were calculated as follows.

$$\text{Energy-use efficiency} = \frac{\text{Output energy (Mj/ha)}}{\text{Input energy (Mj/ha)}}$$

$$\text{Energy Production} = \frac{\text{Grain yield (kg/ha)}}{\text{Input energy (Mj/ha)}}$$

$$\text{Specific energy} = \frac{\text{Input energy (Mj/ha)}}{\text{Grain yield (kg/ha)}}$$

RESULTS AND DISCUSSION

Yield attributes

Pooled data presented in Table 1 indicate that, plant height, number of pods/plant, 100-kernel weight and shelling (%) were significantly influenced due to different land-configuration treatments. Groundnut sown on broad bed and furrow showed significantly highest yield-attributing characters over conventional sowing method. However, pods/plant were significantly higher in raised bed and furrow method of sowing but was at par with that in broad bed furrow method. Rao *et al*. (1991) reported that dry-mater, number of effective pods/plant and shelling percentage of groundnut variety 'ICGS 11' were significantly higher in broad bed and furrow than in flat seedbed. Broad bed and furrow resulted in 21.9% more yield than the flat bed method.

There was significant difference for plant height, pods/plant, 100-kernel weight and shelling (%) of groundnut due to different mulching treatments. Groundnut sowing with transparent polythene mulch noticed significantly higher plant height, pods/plant and 100-kernel weight over no mulch (control), but was at par with sowing groundnut with paddy straw mulching. Moreover, shelling (%) was significantly higher in paddy straw mulch treatment than the control (no mulch) and at par with polythene mulching (Table 1). Zagade and Chavan (2006) reported that, polythene mulch resulted significantly higher values of the growth attributing characters such as plant height, number of leaves, branches and dry-matter accumulation/plant, and yield attributing characters like number and weight of mature pods and number of kernels/pod, 100- kernel weight, shelling percentage, dry pod and haulm yield/ ha than no mulch.

Yield

The dry pod yield of groundnut was significantly higher (2.48 t/ha) under treatment broad bed and furrow (BBF) ridges and furrow, raised bed and furrow and flat bed sowing of groundnut. The increase in dry pod yield owing to sowing on broad bed and furrow over conventional method was to the tune of 26.77%. Groundnut sown on broad bed and furrow method recorded more haulm yield (2.98 t/ha) than ridges and furrow, raised bed and furrow and flat bed sowing methods. Broad bed and furrow (BBF) method provided the loose soil mass with adequate soil moisture by retaining soil moisture. This situation is congenial for easy peg penetration, pod development and thereby the shelling (%), thus enabling the plants to express their potential to large extent, which was reflected in increasing the dry pod yield and subsequently kernel and haulm yields of groundnut. These results are in hormone with the findings of Patil (1991), Sonwalkar (2005) and Subrahmaniyan and Kalaiselvan (2006). Venkateshwarlu (1986) reported that broad bed and furrow method of sowing exhibited yield advantage of about 20% over the flat bed method owing to increased moisture retention for extended times. Similarly, the on-farm trials conducted by the ICRISAT (1991) reported that better performance of groundnut grown on the broad bed and furrow system of planting (BBF) were observed than those grown on flat land. Pawar *et al.* (2000) and they reported that, pod yield increase of 7.5% under broad bed and furrow method than that of flat beds. The environmental conditions in respect of soil-water-plant relationship largely influenced the pod formation and development in broad bed furrow, which also provided loose soil mass, adequate soil moisture and air tends to increased yield.

The groundnut sowing with polythene mulch recorded significantly highest pod, kernel and haulm yield (2.50 t, 1.79 t and 3.01 t/ha respectively) over sowing with paddy straw mulch and no mulch (control). Increase in dry pod yield owing to use of biodegradable polythene mulch was to the magnitude of 12.92% and 32.0% over paddy straw mulch and no mulch (control) respectively. Moreover, haulm yield was 21.92% higher under polythene mulched condition over no mulch (Table 1). This might be owing to better growth and development of crop under mulched condition resulting from better moisture conservation and creation of more congenial growing condition under mulching (Kathmale *et al.* 2000) also observed that haulm yield was significantly more under mulched condition as compared to unmulched one. The exploitation of mulching tends cause significant increment in pod yield of groundnut. The higher yield of groundnut with use of mulch was attributed to conservation of soil moisture and regulation of soil temperature by mulching, which led to production of higher yield attributes and ultimately reflected in higher pod yield (Cheong *el al.,* 1995; Sanjeev *et al.,* 200l; Sounda *et al.,* 2006). This might be because of the beneficial effect of polythene mulch in terms of higher soil temperature and water which might have resulted into better root growth, microbial activities, nutrient availability and hence better growth and yield performance of groundnut crop under polythene mulch than under no mulch.

Economics

The data presented in Table 5 indicate that Groundnut sown with broad bed and furrow (BBF) method resulted in higher net returns (31,392/ ha) and benefit: cost ratio of 1.41 : 1, which was followed by groundnut sown with

Table 1. Effect of land configuration on yield and yield attributes of groundnut during the rainy seasons of 2013–15 (pooled data 3 years)

Treatment	Dry pod yield (t/ha)	Haulm yield (t/ha)	Plant height (cm)	Pods/plant	100-kernel weight (g)	Shelling (%)
Land configuration						
L_1, Conventional method	1.81	2.42	54.1	13.6	57.8	71.7
L_2, Broad bed and furrow method	2.48	2.98	55.2	18.2	61.2	72.5
L_3, Ridge and furrow method	1.99	2.58	50.3	15.2	59.9	71.0
L_4, Raised bed and furrow (30 cm width with 30 cm furrow)	2.23	2.79	53.8	18.4	60.0	71.2
SEm±	0.04	0.05	1.0	0.4	0.4	0.2
CD (P=0.05)	0.11	0.16	3.1	1.2	1.2	0.6
Mulching						
M_1, Control	1.70	2.35	49.8	13.8	57.6	71.0
M_2, Organic mulch, i.e. paddy straw mulch	2.18	2.72	52.3	17.2	60.8	72.2
M_3, Biodegradable polythene mulch	2.50	3.01	57.9	18.0	60.9	71.6
SEm±	0.03	0.04	0.7	0.3	0.3	0.2
CD (P=0.05)	0.09	0.12	2.1	0.8	0.9	0.6
Interaction effect						
SEm±	0.06	0.08	1.5	0.6	0.6	0.4
CD (P=0.05)	0.17	0.24	NS	1.6	1.8	NS

Table 2. Interaction effect between land configuration and mulching on dry pod, kernel and haulm yield (t/ha) of groundnut (pooled data of 3 years)

Treatment	Dry pod yield (t/ ha)					Kernel yield (t/ ha)					Haulm yield (t/ha)				
	L_1	L_2	L_3	L_4	Mean	L_1	L_2	L_3	L_4	Mean	L_1	L_2	L_3	L_4	Mean
M_1	1.50	1.89	1.53	1.88	1.70	1.06	1.38	1.07	1.33	1.21	2.06	2.45	2.34	2.54	2.35
M_2	1.76	2.70	1.98	2.27	2.18	1.28	1.96	1.43	1.63	1.57	2.45	3.01	2.63	2.78	2.72
M_3	2.18	2.84	2.44	2.54	2.50	1.57	2.06	1.73	1.81	1.79	2.75	3.47	2.76	3.07	3.01
Mean	1.81	2.48	1.99	2.23	2.13	1.30	1.80	1.41	1.59	1.52	2.42	2.98	2.58	2.79	2.69
Comp means of	SEm±			CD (P=0.05)		SEm±			CD (P=0.05)		SEm±			CD (P=0.05)	
Main plot (L)	0.04			0.11		0.03			0.08		0.05			0.16	
Sub-plot (M)	0.03			0.09		0.02			0.06		0.04			0.12	
L X M	0.06			0.17		0.05			0.13		0.08			0.24	
CV (L, M)	9.03			8.60		8.79			8.92		10.39			9.24	

Detail of treatments are given in table 3

raised bed and furrow method. However, use of polythene mulch for groundnut sowing noticed higher net returns of 26,341/ha with benefit: cost ratio of 1.32 : 1 and this was followed by groundnut sowing with paddy straw mulch. Similar kind of results were observed by Ghosh *et al.,* (2006) who reported thin film of mulch (gauge, 5–7 mm), which is relatively a cheaper may be a right proposition for groundnut.

Interaction effect

The interaction effects between land configuration and mulching was found to be significant for dry pod, kernel and haulm yield of groundnut. Groundnut sowing on broad bed and furrows (80–20 cm) with biodegradable polythene mulch (L_2M_3) recorded significantly higher dry pod, kernel and haulm yield (2.84, 2.06 and 3.47 t/ha respectively) over rest of the treatment combinations but was at par with broad bed and furrow sowing and paddy straw mulch application treatment combination for pod and kernel (2.70 t and 1.96 t/ha respectively) yield of groundnut (Table 2).

Field water use efficiency

The results regarding to field water use efficiency in Table 4 indicated that groundnut sown on broad bed and furrows under transparent polythene mulch was found to be the highest field water-use efficiency of 1.77 kg/ha mm, which was closely followed by same land configuration method with paddy straw mulch treatment (1.73 kg/ha mm). The higher water-use efficiency under mulched condition might be owing to increased level of water-holding capacity of soil. Application of polythene mulch or rice

Table 3. Energy indices for groundnut production

Sl. No.	Input	Energy equivalent (MJ/unit)
1.	Human labour (M)	1.96
	Human labour (F)	1.57
2.	Tractor	138
3.	Fertilizers	
	Farm yard manure (kg)	0.3
	Nitrogen (N) (kg)	60.60
	Phosphorus (P_2O_5) (kg)	11.10
	Potassium (K_2O) (kg)	6.70
4.	Insecticide (kg)	278
5.	Groundnut seed (kg)	14.70
6.	Fuel (litre)	56.31
7.	Electricity	11.93
8.	Plastic mulching	130 labour for 55 kg/ha
9.	Paddy straw mulching	100 labour for 5.0 t/ha
10.	Pod yield (kg)	14.70
11.	By produce yield (kg)	12.50

Sources: Mittal and Dhawan (1988), Mandal *et al.*, (2015) straw mulch decreased the depletion of soil moisture due to less evaporation, resulting in better availability of moisture which in turn increased the availability of plant nutrients in soil and their uptake by plant led to produce increased yield of the crop as reported by Dutta (2006). In the same way, Singh *et al*. (2007) reported that total water used by greengram in flat planting and bed planting which indicated 34.75% saving in total water used under bed planting than that under flat planting without substantial effect on grain yield.

Energy study

Groundnut sown on broad bed and furrow method with transparent polythene mulch noticed the highest energy output of 84,101 MJ/ha and groundnut sown on flat bed without mulch had lowest energy output of 39,939 MJ/ha among the treatment combinations. Groundnut sown on broad bed and furrow method with transparent polythene mulch recorded highest energy balance (63,629 MJ/ha), with higher energy balance per unit input 3.11 MJ/ha and energy-use efficiency of 4.11. Energy specific for broad bed and furrow method with transparent polythene mulch treatment was 7.26 MJ/kg, which indicated 7.26 MJ energy is needed to obtain 1 kg of groundnut. However, energy productivity is 0.14 kg/MJ which means that, 0.14 kg of output was obtained per unit energy with broad bed and furrow and transparent polythene mulch method (Table 4).

It was concluded from the present investigation that, higher productivity and profitability from the rainy (*kharif*) groundnut was obtained by sowing groundnut on broad bed and furrow (80–20 cm) with 44 kg/ha transparent polythene mulch under lateritic soils of Konkan. Energy use is one of the key indicators of developing sustainable agriculture practice, to obtain higher energy balance per unit of input and energy productivity. Groundnut sown on broad bed and furrow under transparent polythene mulch

Table 4. Field water-use efficiency and energy study of groundnut as influenced by different treatments

Treatment	Dry pod yield (kg/ha)	Field water use efficiency (kg/ha-mm)	Energy output (MJ/ha)	Energy input (MJ/ha)	Energy balance (MJ/ha)	Energy balance per unit input(MJ/ha)	Energy use efficiency	Energy specific (MJ/kg)	Energy Productivity (kg/MJ)
L_1M_1	1501	0.98	39,939	19,971	19,968	1.00	2.00	15.98	0.06
L_1M_2	1761	1.16	50,383	20,249	30,134	1.49	2.49	12.73	0.08
L_1M_3	2180	1.47	52,963	19,809	33,154	1.67	2.67	11.71	0.09
L_2M_1	1890	1.19	68,584	19,463	49,121	2.52	3.52	8.74	0.11
L_2M_2	2699	1.73	68,584	19,463	49,121	2.52	3.52	7.54	0.13
L_2M_3	2842	1.77	84,101	20,473	63,629	3.11	4.11	7.26	0.14
L_3M_1	1531	1.00	53,369	20,282	33,087	1.63	2.63	13.23	0.08
L_3M_2	1982	1.34	55,563	20,588	34,976	1.70	2.70	11.29	0.09
L_3M_3	2442	1.53	68,511	20,744	47,767	2.30	3.30	8.67	0.12
L_4M_1	1878	1.20	62,560	20,134	42,426	2.11	3.11	10.04	0.10
L_4M_2	2268	1.48	67,996	20,351	47,645	2.34	3.34	9.23	0.11
L_4M_3	2537	1.64	72,570	20,469	52,101	2.55	3.55	8.46	0.12
Mean	2126	1.37	62,094	20,166	41,927	2.08	3.08	10.41	0.10

Rainfall received

Table 5. Economics of groundnut as influenced by land configuration and mulching treatments (pooled data of 3 years)

Treatment	Cost of cultivation ($\times 10^3$ ₹/ha)	Gross returns ($\times 10^3$ ₹/ha)	Net returns ($\times 10^3$ ₹/ha)	Benefit: cost ratio
Land configuration				
L_1, Conventional method	72.6	78.9	6.3	1.09
L_2, Broad bed and furrow method	77.2	108.6	31.4	1.41
L_3, Ridge and furrow method	76.9	86.7	9.8	1.13
L_4, Raised bed and furrow (30 cm width with 30 cm furrow)	74.4	97.3	22.8	1.31
Mulching				
M_1, Control	65.9	74.7	8.8	1.14
M_2, Organic mulch, i.e. paddy straw mulch	77.1	94.7	17.6	1.23
M_3, Biodegradable polythene mulch	82.9	109.2	26.3	1.32

Table 6. Produce and input rates in land configuration and mulching treatments of groundnut

Kharif season	Groundnut pod (₹/kg)	Haulm (₹/kg)	Labour ₹/day	N ₹/kg	P_2O_5 ₹/kg	FYM ₹/tonne	Groundnut seed (Pod) (₹/kg)	Paddy straw mulch (kg)	Mulch paper (₹/kg)
2013	35.0	1.5	120.0	12.2	37.5	1000.0	63.0	1.5	160
2014	45.0	1.5	180.0	12.2	37.5	1000.0	63.0	1.5	160
2015	45.0	1.5	180.0	12.2	37.5	1000.0	63.0	1.5	160

Land configuration treatment	Polythene mulch required (₹/ha)	Paddy straw required (kg/ha)
L_1, Conventional method	55.00	5,000
L_2, Broad bed and furrow method	44.00	4,000
L_3, Ridge and furrow method	55.00	5,000
L_4, Raised bed and furrow (30 cm width with 30 cm furrow)	27.50	2,500

recorded higher energy balance of 63,629 MJ/ha, with higher energy use efficiency (4.11) and 7.26 MJ/kg of energy specific.

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