Jour. Agric. Physics, Vol. 1, No. 1, pp. 151-155 (2001)

Effect of Surface Drainage on the Production Potential of Pigeonpea in High Rainfall Vertisols

S.S. TOMAR, G.P. TEMBE, S.K. SHARMA
J.N. Krishi Vishwa Vidyalaya, Jabalpur 482 004 (M.P.)

ABSTRACT

In field experiments carried out during 1990-1995 at the Experimental Station, J.N. Krishi Vishwa Vidyalaya, Jabalpur, maximum average seed yields of soybean, pigeonpea and black gram were recorded in 6m wide raised beds followed by 9m wide raised bed and minimum in flat plots. Highest productivity of soybean + pigeonpea and black gram + pigeonpea was recorded in 6 or 9m wide raised beds in different seasons because of adequate surface drainage for upland crops. Economic viability analysis of RSB system indicated a net return of Rs. 13745 ha^{-1} per annum. In Vertisols of dependable high rainfall (>1000 cm) areas, the raised beds of 6 to 9m width and 0.35 cm high along with the sunken beds of 6m width are recommended for increasing productivity of pigeonpea, black gram and soybean and to increase the income of the farmers of this region.

Introduction

In central and eastern part of India there are extensive areas of black clay soils which are not efficiently used for growing kharif pulses and oilseeds because these crops are very sensitive to waterlogging at early stages of growth (Tomar *et al.*, 1996,1997). Inequitable distribution of rains and poor drainage are main causes of low yield of pigeonpea in these areas. The rainfall is highly variable both in time and space. There is excess of water during kharif season and acute deficiency during rabi and summer season. The excess of rain water causes water stagnation and waterlogging in some areas creating unfavourable conditions for kharif pulses particularly soybean, pigeonpea and black gram. Due to these problems, about 18m ha Vertisols and associated soils in the country are kept fallow in kharif season and only rabi crops are raised on profile stored soil moisture (Ryan and Sarin, 1981). In M.P. even after introduction of soybean crop in kharif season, about 4.83 m ha (24.5 % of net sown areas) are kept under fallow in rainy season (Agril. Stat. Staff, 1993).

Considering the major problems of Vertisols region an effort has been made to evaluate the suitable width of raised bed for efficient drainage during rainy season and favourable moisture conditions during critical stages of kharif and rabi crops and enhance the productivity in these areas on sustainable basis.

Materials and Methods

A long term field experiment was carried out at experiment Station of J.N. Krishi Vishwa Vidyalaya, Jabalpur from 1990 to 1995 in *kharif* season. The soil of the experimental site was deep fine textured montmorillonitic family of typic Haplusterts. The surface soil (55% clay, 27% silt and 18% sand) had pH 7.5, $CaCO_3$ 3.5% and organic carbon 0.5%. Moisture content at 33 and 1500 kPa suction of undisturbed soil sample of surface soil (0.20 m) was 0.317 and 0.20 m^3m^{-3}, respectively. The profile was uniform in clay content, although the bulk density increased with depth and ranged from 1.16 to 1.70 Mgm^{-3} from surface to 1.8 m depth. The rainfall is mainly concentrated in four rainy season months from mid June to mid October and varies from 1200 to 1500 mm per annum with frequent droughts after 3 or 4 years.

About 1 ha field shaped into array of raised and sunken beds, consisting of four widths of raised beds viz. 6, 9, 12 and 15m wide and 0.30m high running in parallel of sunken beds of 6m width. The beds were created mechanically by shifting the surface soil from adjoining sunken beds to raised beds. Details of construction of raised - sunken bed system (RSB) was reported earlier (Tomar *et al.*, 1996). In first year sunken beds were fertilized with recommended doses of FYM and Zinc sulphate to take care of sub-soil fertility. During *kharif* season pigeonpea (*Cajanus cajan* L.), Cv. "T-148", soybean (*Glycin max* L. Merrill) cv. "JS 7546" and black gram (*Phaseolus mungo*) cv. "T-8" were planted in raised beds invariably during first week of July in all the years as sole and as intercrop. Short duration paddy (*Oryza sativa* L.) cv. "Purva" was planted in sunken beds. To observe changes in soil moisture content periodic moisture sampling was carried out in 0.05m, 1.5m, 3m away in 6m raised bed and

Table 1. Effect of surface drainage on the grain yield (kg ha^{-1}) of soybean and pigeonpea grown as sole and intercrop in the Vertisols of high rainfall area

Raised bed width (m)	Cropping system	Years						
		90-91	91-92	92-93	93-94	94-95	95-96	Av.
6	Soybean sole	2425	2523	3107	1733	1969	1755	2252
	Pigeonpea sole	2012	2004	2532	1825	1626	1174	1862
	Soybean +	1805	1977	310	1433	1631	1344	1750
	Pigeonpea	1806	1608	2394	1436	1429	Nil	1735
9	Soybean sole	2329	2287	2738	1600	1904	1714	2095
	Pigeonpea sole	1961	1709	2327	1800	1527	1114	1740
	Soybean +	1851	1677	1696	1048	1187	1175	1439
	Pigeonpea	1655	1446	1868	1344	1430	Nil	1548
12	Soybean sole	2292	2147	2497	1444	1736	1691	1968
	Pigeonpea sole	1687	1496	2003	1414	1244	1091	1486
	Soybean +	1676	1523	1586	992	1181	1096	1342
	Pigeonpea	1313	1092	1438	1559	1140	Nil	1308
15	Soybean sole	2014	1992	2124	1495	1628	1254	1751
	Pigeonpea sole	1003	945	1580	1905	1200	654	1215
	Soybean +	1475	1448	1522	1136	1122	1105	1301
	Pigeonpea	1052	852	1244	1451	1136	Nil	1147
Flat 6m	Soybean sole	849	125	581	1050	1469	1113	865
	Pigeonoea sole	128	167	Nil	Nil	Nil	Nil	148
	Soybean +	650	95	581	1050	1469	1113	373
	Pigeonpea	125	151	Nil	Nil	Nil	Nil	138
Season rainfall (mm)		1737	1125	1161	1393	1823	1036	1379
CD 5%	Soybean sole	39.0	182.0	398.8	156.3	242.6	206.3	
	Pigeonpea sole	297.1	178.05	253.02	NS	304.0	243.0	
	Soybean +	123.95	96.39	235.3	164.7	274.0	NS	
	Pigeonpea	72.19	224.34	239.7	NS	140.2	Nil	

1.5m, 3m and 6m away in 12m wide raised beds. At the same points piezometers were also installed to monitor the water table depth during the growing period of crops. All the crops were harvested at physiological maturity.

Results and Discussion

The average seed yield of sole soybean over a period of six years varied from 865 to 2252 kg ha^{-1} in flat and raised bed plots, respectively. Highest grain yield of both pigeonpea + soybean was recorded in 6m wide raised beds in all the years and was statistically significant from other widths of raised beds (Table 1). Data presented in table 2 indicated that highest average grain yield of black gram (944 kg ha^{-1}) and pigeonpea (2183 kg ha^{-1}) were also observed on 6m wide raised bed followed by other width of raised beds and minimum in flat plots. The year to year variations observed in the grain yield of these crops may be because of variations in amount and distribution of rainfall. However, based on average grain yield data of five years, it could be inferred that the poor drainage conditions in flat and 15m wide raised beds affected the grain yield of soybean, pigeonpea and black gram grown as sole and intercrop conditions. Six or 9m wide raised beds provided rapid drainage to upland crops during intensive rains (July and August) and enough ponding of water in sunken beds. Also, the development of

Table 2. Effect of surface drainage on the grain yield (kg ha^{-1}) of black gram and pigeonpea grown as sole and intercrop in Vertisols of high rainfall area

Raised bed width (m)	Cropping system	Years			
		90-91	91-92	92-93	Average
6	Black gram sole	1023	872	936	944
	Pigeonpea sole	2012	2004	2532	2183
	Black gram +	780	681	578	679
	Pigeonpea	1522	1482	2323	1776
9	Black gram sole	991	881	826	879
	Pigeonpea sole	1861	1709	2327	1966
	Black gram +	667	597	585	616
	Pigeon pea	1116	1125	1607	1283
12	Black gram sole	9054	700	827	814
	Pigeonpea sole	1687	1496	2003	1729
	Black gram +	661	552	551	591
	Pigeonpea	1116	1125	1607	1283
15	Black gram sole	712	572	604	631
	Pigeonpea sole	1003	945	1580	1176
	Black gram +	605	489	451	515
	Pigeonpea	825	825	1196	958
Flat 6m	Black gram sole	500	112	Nil	306
	Pigeonpea sole	128	167	Nil	147
	Black gram +	271	113	Nil	192
	Pigeonpea	130	90	Nil	210
CD 5%	Black gram sole	19.0	102.70	197.2	
	Pigeonpea sole	136.34	178.65	253.2	
	Black gram +	122.50	108.63	128.9	
	Pigeonpea	20.36	222.40	265.85	

Table 3. Lateral soil moisture distribution on raised beds (% θv) during growth period of pigeonpea

Soil depth	Raised bed (6m)			Raised bed (12 m)			
	0.5 m	1.5 m	3 m	0.5 m	1.5 m	3 m	6 m
			24.7.94				
0-10	33.15	31.60	30.16	34.96	33.14	32.90	32.02
10-20	34.90	32.44	31.70	35.86	34.22	34.06	33.80
20-30	35.60	33.59	32.11	36.90	34.96	34.10	33.46
			21.8.94				
0-10	33.60	31.50	31.44	36.12	34.90	33.44	32.10
10-20	35.80	32.90	32.02	36.96	36.96	34.80	33.90
20-30	36.44	33.70	32.33	37.40	37.29	35.60	35.11
			7.9.94				
0-10	32.14	31.60	30.20	34.49	34.90	33.14	32.20
10-20	33.19	31.70	30.96	35.14	36.96	34.96	31.40
20-30	35.36	32.44	31.44	39.42	39.44	37.14	35.11
			5.10.94				
0-10	28.16	26.14	25.90	24.16	23.20	21.20	20.80
10-20	30.26	28.42	26.59	25.90	24.16	22.90	21.90
20-30	31.96	30.22	28.36	26.99	25.11	23.60	22.44

Table 4. Water table depth (cm) on specific days during crop growth period measured on 6m and 12m wide raised beds

Dates	6 m wide R.B.			12 m wide R.B.			
	0.5	1.5	3m	0.5	1.5	3	6m
30.7.94	29	29.0	31.0	20.0	26.0	21.0	22.0
1.8.94	-	Surface	-	-	Surface	-	-
3.8.94	28.0	29.0	30.0	24.0	19.0	19.5	17.0
4.8.94	-	Surface	-	-	Surface	-	-
6.8.94	30.0	31.0	31.0	28.0	27.0	25.5	24.0
8.8.94	-	Surface	-	-	Surface	-	-
10.8.94	34.0	37.0	37.5	20.0	26.0	23.0	22.0
12.8.94	37.0	39.0	37.0	25.0	30.0	26.0	24.5
14.8.94	35.0	39.5	39.0	22.0	26.5	30.0	29.5
16.8.94	31.0	35.0	34.0	20.0	18.5	17.0	12.0
18.8.94	26.5	28.5	28.0	22.5	18.0	7.0	8.0
20.8.94	29.0	36.0	35.5	26.5	29.5	25.5	25.0
22.8.94	35.0	36.0	36.9	18.0	19.5	21.5	26.5
24.8.94	24.5	30.0	31.0	20.0	13.5	13.5	10.6
26.8.94	30.5	31.0	32.0	25.0	20.0	16.5	15.4

Table 5. Economic viability analysis of RSB system in Vertisols of central India

Treatment combinations (one ha)	Operational cost (Rs.)	Yield (q ha^{-1}) Gross	Return (Rs. ha^{-1}) Net	ratio	C/B
RAIS : Soybean - Gram	9269	24.46, 17.31	21,894	12625	1:2.36
SUN : Paddy - Gram		27.92, 14.49			
RAIS : Pigeonpea + soybeam	7919	18.81 + 18.11	21664	13745	1:2.73
SUN : Paddy-Gram		17.92, 14.49			
RAIS : Pigeonpea	6759	20.93	16209	9450	1:2.40
SUn : Paddy - Gram		27.92	14.49		

RAIS - Raised bed; Sun - Sunken bed

high moisture stress in root zone of upland crops, if any, during the later growth periods was avoided due to movement of water from sunken beds to the root zone of soybean, pigeonpea and black gram in raised beds (Table 3). Therefore, better yield of upland kharif crops on raised beds as compared to flat plots could be attributed to better surface drainage and hence better soil aeration as reflected from soil moisture and water table depth data (Tables 3 and 4). The surface layer of 6m wide raised beds had also shown lower water table depth during continuous rains, while, higher water table (ponding water conditions) prevailed in 12m wide raised beds and in flat plots (Table 4). Thus lack of adequate surface drainage in 12 or 15m wide raised beds or flat plots caused the stagnation of rain water resulting in poor growth and thereby low grain yield of these crops.

Six years average yield data of pigeonpea grown as a sole and as intercrop in both 6m wide raised beds and sunken beds (table 1) were used to calculate the economic viability analysis of RSB system. The highest net return (Rs. 13745 ha^{-1}) was observed in pigeonpea + soybean intercrop on raised beds and paddy—chickpea in sunken beds in different years (Table 5). These results further revealed that the net return from soybean

+ pigeonpea inter cropping in raised beds was very high as compared to return obtained under farmer's conditions. Best benefit cost ratio was observed in pigeonpea + soybean in raised beds and paddy and chickpea cropping sequence in sunken beds followed by pigeonpea + soybean in raised beds and paddy and wheat in sunken beds.

Based on the present study carried out over 5 years it can be concluded that RSB system will help in reducing kharif fallowing which is a common practice in black soil region, increasing cropping intensity as well as net income of the farmers. The inter cropping of pigeonpea + soybean in raised beds and paddy-chickpea in sunken beds fulfil the need of small farmers of black soil zone, with the aim to optimize physical environment, minimize runoff and erosion and conserve nutrients and water *in situ* and attain high income.

References

Agril. Stat. Staff 1993. Agriculture Statistics of Madhya Pradesh (1990-91). *Directorate of Agriculture*, M.P., Bhopal.

Ryan, R.G. and Sarin, R. 1981. Economics of technology options for Vertisols in relatively dependable rainfall regions of India. SAT pp. 37-57. *In* : Management of *deep black soils for increased production of cereals*, pulses and oilseeds. Proceeding Seminar ICRISAT, Hyderabad, India.

Tomar, S.S., Tembe, G.P., Sharma, S.K., Bhadauria, U.P.S. and Tomar, V.S. 1996. Improvement of soil physical conditions of black soils of Madhya Pradesh, Research Bulletin, Department of Soil Science & Agril. Chemistry, JNKVV, Jabalpur, pp. 96.

Tomar, S.S., Tembe, G.P., Sharma, S.K., Bhadauria, U.P.S. and Shrivastava, S.P. 1997. Soil physical constraints and their management for increasing agricultural produciton in Madhya Pradesh. QRT Report, ICAR-AICRP on "Tillage Requirement of Major India soil for different cropping system", pp. 143.