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Parameters that influence the mole drain (pipeless) formation in vertislos of M.P.

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ABSTRACT : A 75 hp tractor operated mole plough was used in the formation at 2 m, 4 m, 6 m and 8 m spacing at an average depth of 0.4 m, 0.5 m and 0.6 m from ground surface at farmer's fields in Hoshangabad district of Madhya Pradesh in vertisols. The average length of each lateral was 50 m and the tractor was operated at a speed of 0.80 kmph. Mole drains can be formed in Vertisols at different treatment when the average soil moisture content is between 22.7 - 26 % and average clay content is 52.31% at moling depth. The bulk density was not affected under control (no mole drain formation) in all the stages. While in case of mole drain creation, a considerable reduction in bulk densities was observed due to presence of macropores developed by the moling . The highest reduction in bulk density was recorded under treatment S_1D_1 (2 m spacing x 0.4 m depth) among all the treatments. Finally it may be concluded that the mole drains are best option for the water logged and heavy soils and it is the most appropriate, profitable and productive practice for soybean under vertisols of Madhya Pradesh.

KEY WORDS : Drainage, Mole drains, Mole drainage system, Vertisols

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Mole drains are pipeless drains that are formed with a mole plough. The mole plough consists of a cylindrical foot attached to a narrow leg. Connected to the back of the foot is a slightly larger diameter cylindrical expander. The foot and expander form the drainage channel as the implement is drawn through the soil and the leg leaves a slot and associated fissures. The fissures extend from the surface and laterally out into the soil. Any surplus water above moling depth can therefore, move, rapidly through these fissures into the mole channel. Mole drains are generally installed at a depth varying between 40 to 60 cm below the surface. The mole drains should be deep enough to be protected from the loads of heavy farm machinery and from the swelling and thawing effect of vertisols. The spacing of mole drains generally varies from 2 to 10 m. However, it depends on the soil permeability and the necessity of drainage also. If the spacing is less than 2 m, there is a danger of damage of the previously constructed drain, where as if the spacing is greater than 5 m, the fissuring effect may not cover the intervening space. Local experience rather than the adopting a particular value determines the spacing of the mole drain. The length of mole channels depends on the grade of the mole drains formed, soil type, shape, size and topography of the field. Flat slopes require shorter drain. A balance has to be found between risk of scouring with high water velocities on deep grades and risk of pond and channel collapse at low grades inorder to decide the length and grade of mole channel. In order to protect the outlet of mole drain, a small piece of approximately 1 m length PVC pipe is inserted at the outlet side of the drain. For longer life of mole drains, the timing of the installation is very critical. At the time of moling the soil at moling depth should be plastic and soil above this depth should be friable so that there is adequate traction and the soil will crack well from the leg slot to the soil surface. The ideal time for moling after one to two months after monsoon rains withdraws. Immediately after mole drains installation it would be better irrigate the field with sprinklers otherwise do not irrigate at all at least for a month, allowing the soil to ripen before the mole carries water. The useful life of mole channels varies from 2 to 10 years depending upon many factors. Success of moling depends on working with the correct soil type, and installing the mole drainage at the right depth and spacing at a optimum moisture content *i.e.*, near the lower limit of the 'plastic' range. The speed of operation of mole plough for mole drain formation is very important. Better mole drains are formed when the tractor speed is slow and steady. The generally recommended speed is less than 1.0 kmph.

METHODOLOGY

The study area is located in the farmer's fields in the village Bamuriya in Hoshangabad district of Madhya Pradesh. The study area is situated between $22^0$37'30'' to $22^0$38'10'' N latitude and $77^0$39'30" to $77^0$40'59" E longitude with an altitude of 307 meters from mean sea level (MSL). The slope of the area is less than 1% with good drainage outlets.The dimensions of the mole plough designed and developed at CIAE include a leg with 1250 × 250 × 25 mm and a foot of 63 mm with 75 mm bullet or expander diameter. With a 3 point linkage the plough can be mounted on a wheeled tractor. The total weight of the plough was 75 kg. The success of a mole drainage system depends on the correct soil type, soil physical parameters, drain depth and spacing and doing the work at the appropriate time of the year. At the time of moling the soil at moling depth was plastic. The treatments consisted of 13 combinations of mole drain spacing (4 levels) and mole drain depth (3 levels).

The details of treatment combinations are given in Table A. The mole drains installed 4 spacing (2m,4m,6m and 8m spacing) at 3 depths (0.4m,0.5m and 0.6 m depth) under a split plot designed experiment with 3 replications.

Table A : Detail of treatment combination for mole drains spacing and depths

Symbol	Treatments detail for soybean crop
T_0	S_0D_0 (Control)
T_1	S_1D_1 (spacing 2 m + depth 0.4 m)
T_2	S_1D_2 (spacing 2 m + depth 0.5 m)
T_3	S_1D_3 (spacing 2 m + depth 0.6 m)
T_4	S_2D_1 (spacing 4 m + depth 0.4 m)
T_5	S_2D_2 spacing 4 m + depth 0.5 m)
T_6	S_2D_3 (spacing 4 m + depth 0.6 m)
T_7	S_3D_1 (Mole spacing 6 m + depth 0.4 m)
T_8	S_3D_2 (Mole spacing 6 m + depth 0.5 m)
T_9	S_3D_3 (Mole spacing 6 m + depth 0.6 m)
T_{10}	S_4D_1 (Mole spacing 8 m + depth 0.4 m)
T_{11}	S_4D_2 (Mole spacing 8 m + depth 0.5 m)
T_{12}	S_4D_3 (Mole spacing 8 m + depth 0.6 m)

Selection of design parameters for mole drainage system:

Mole drain depth and spacing are usually not computed. The low installation cost, generally does not justify the expense of investigations and allows for a close spacing, with a great safety margin. Although the spacing is related to soil texture in some countries in Eastern Europe, it is largely determined based on local experience in most countries (Jha and Koga, 2002).

Spacing of mole drains:

To ensure proper fissuring of the soil through the area,the spacing of mole drains varies from 2 to 5 m is commonly applied (Theobald, 1963). If the spacing is less than 2 m, there is a danger of damage of the previously constructed drain where as if the spacing is greater than 5 m the fissuring effect may not cover the intervening space. However, it depends on the soil permeability and the necessity of drainage also. Ramana Rao *et al.* (2009) found that mole drains constructed at 2 m, 4 m and 6 m spacing and depth 60 cm, drains are functioning well since last five years and more effective in soybean crop. So the 2 m, 4 m, 6 m and 8 m spacing between the mole drains channels was selected for the study.

Depth of mole drains:

Mole channel should be deep enough to be protected from the load of heavy farm machinery and from the climatic phenomena. Moreover, the deeper the channels are, the greater is the extent of fissuring. However, installation costs increase with depth. Suitable depths are found to be 45-55 cm in New Zealand and 70-90 cm in Eastern Europe (Raadsma,1974). Soucek (1965) suggested pipeless drains should be installed in the depth range of 55-80 cm *i.e.* at a depth at which they will attain the highest stability. According to Cavellars (1974), pipeless drains are limiting in depth depending on the power available to construct drains and efficiency of the drainage system. In practices, a mole drains depth of 40 to 60 cm from the soil surface is normally adopted (Jha and Koga, 2002). So the 0.4 m, 0.5 m, and 0.6 m depth of mole drains were selected for the study.

Length of mole drains:

The length of mole channels depends on the grade of the mole drains formed, soil type, shape, size and topography of the field. Flat slope requires shorter drain. Generally adopted/accepted maximum effective length of moles is 200 m. Safe drain lengths vary from 20 to 80 m and should be decided on the basis of local experience (Smedema and Rycroft, 1983). So 50 m length of mole drain was selected.

Outlet of mole drains:

Just after the mole drains installation, the loose soil should be removed from the outlet and 1 to 3 m pipe should be inserted into the mole drain channel to prevent outlet destruction and soil erosion (Husson *et al.*, 1962). So low cost PVC pipe of 1 to 3 m size was selected for outlet of mole drains.

RESULTS AND DISCUSSION

The experimental findings obtained from the present study have been discussed in following heads:

Soil physical properties for mole drains formation:

Success of formation of mole drains depends on the soil physicals properties. Therefore, soil properties like soil texture, soil moisture and bulk density were determined at time of mole drains formation. The Table 1 presents the soil physical properties for mole drains formation in Vertisols. It was found that mole drains can be formed in Vertisols at different treatment when the average soil moisture content was between 22.7 - 26 % and average clay content is 52.31% at moling depth. The average bulk density recorded at soil depth 40-50 cm and 50-60 cm were 1.431 and 1.556 g/cc, respectively. Similar findings were also observed by Jha and Koga (1995); Mueller and Schindler (1992) and Ramana Rao *et al.* (2009).

Field capacity of mole plough at the time of mole drains formation:

The data in Table 2 reveal that effect on field capacity of mole plough for mole drains formation were recorded highest under S_4D_3 (mole drains at the spacing of 8m on the depth of 0.4 m) and lowest under S_1D_3 (mole drains at the spacing of 2 m on the depth of 0.4 m) in the year 2009-10. Field

Table 1 : Soil physical properties for mole drains formation in Vertisols

Treatments	Soil texture (%) at 40-60 cm soil depth			Soil moisture content (%)		Bulk density (g/cc)	
	Sand	Silt	Clay	At 40-50 cm soil depth	At 50-60 cm soil depth	At 40-50 cm soil depth	At 50-60 cm soil depth
S_0D_0	21.86	25.90	52.24	22.5	25.7	1.435	1.571
S_1D_1	22.42	25.92	51.66	21.7	24.9	1.435	1.553
S_1D_2	23.48	24.42	52.10	23.2	26.6	1.429	1.568
S_1D_3	21.02	26.12	52.86	22.2	25.5	1.427	1.555
S_2D_1	22.12	24.88	53.00	21.9	25.2	1.437	1.567
S_2D_2	23.28	25.32	51.40	24.4	27.1	1.436	1.555
S_2D_3	24.26	23.22	52.52	22.6	25.6	1.429	1.562
S_3D_1	21.16	26.32	52.52	24.2	26.8	1.428	1.550
S_3D_2	23.02	24.02	52.96	21.4	24.8	1.431	1.560
S_3D_3	24.02	24.12	51.86	22.8	26.2	1.434	1.549
S_4D_1	21.12	26.08	52.80	24.2	27.8	1.432	1.558
S_4D_2	22.86	24.72	52.42	21.9	26.2	1.429	1.546
S_4D_3	23.12	25.12	51.76	22.4	25.7	1.423	1.540
Average	22.60	25.09	52.31	22.7	26.0	1.431	1.556

Table 2 : Field capacity of mole plough under various mole drain treatments

Treatments	Field capacity of mole plough (ha/hour)
S_0D_0	0.000
S_1D_1	0.183
S_1D_2	0.163
S_1D_3	0.143
S_2D_1	0.370
S_2D_2	0.320
S_2D_3	0.290
S_3D_1	0.557
S_3D_2	0.493
S_3D_3	0.423
S_4D_1	0.720
S_4D_2	0.643
S_4D_3	0.563
S.E.=	0.007
C.D. (P=0.05)	0.023

Table 3 : Effect of interaction S x D on bulk density affected by various treatments

Treatments	Bulk density at depth of 40-50 cm			Bulk density at depth of 50-60 cm		
	Stage I	Stage II	Stage III	Stage I	Stage II	Stage III
S_0D_0: Control	1.435	1.434	1.431	1.571	1.546	1.555
S_1D_1: 2m S x 0.4 m D	1.435	1.310	1.285	1.553	1.382	1.331
S_1D_2: 2m S x 0.5 m D	1.429	1.325	1.296	1.568	1.385	1.338
S_1D_3: 2m S x 0.6 m D	1.427	1.332	1.304	1.555	1.409	1.364
S_2D_1: 4m S x 0.4 m D	1.437	1.339	1.305	1.567	1.429	1.383
S_2D_2: 4m S x 0.5 m D	1.436	1.337	1.312	1.555	1.429	1.370
S_2D_3: 4m S x 0.6 m D	1.429	1.346	1.323	1.562	1.452	1.401
S_3D_1: 6m S x 0.4 m D	1.428	1.350	1.323	1.550	1.469	1.428
S_3D_2: 6m S x 0.5 m D	1.431	1.352	1.322	1.560	1.462	1.442
S_3D_3: 6m S x 0.6 m D	1.434	1.353	1.323	1.549	1.528	1.520
S_4D_1: 8m S x 0.4 m D	1.432	1.356	1.326	1.558	1.542	1.521
S_4D_2: 8m S x 0.5 m D	1.429	1.359	1.328	1.546	1.536	1.548
S_4D_3: 8m S x 0.6 m D	1.423	1.358	1.333	1.540	1.533	1.553
S.E.+	0.003	0.0004	0.002	0.006	0.015	0.011
C.D. (P=0.05)	NS	0.001	0.007	NS	0.038	0.035
Stage I	Initial (before construction of mole drain formation, 2009)					
Stage II	After harvesting of soybean (*Kharif*, 2010)					
Stage III	After harvest of soybean (*Kharif*, 2011)					

NS=Non-significant

capacity of mole plough for mole drains formation was decreasing with depth and increasing with spacing. Similar findings were obtained by Ramana Rao *et al.* (2005) due to pipeless drainage for 2 m, 4 m and 6 m mole drain spacing with 0.6 m mole drain depth.

Effect on bulk density (g/cc) of soil:

The impact of bulk density of the soil was very much pronounced at all depth and spacing of mole drains. Bulk density during the experimental period was measured during the time of moles drains formation in the October 2009 and after harvesting of soybean during both the years 2010 and 2011 at soil depth 40-50 cm and 50-60 cm. The values of bulk density under various treatments are given in Table 3.

On an average, the bulk density of mole drain treatment S_1D_1: 2m S x 0.4 m D decreased during observation period and value of bulk density observed during October 2009 was 1.435 g cm^{-3}, during October 2010 was 1.310 g cm^{-3} and during October 2011 was 1.285 g cm^{-3} for soil depth 40-50 cm. The same trend was found in other treatments also. The data showed a considerable reduction in bulk densities at both the stage under all the treatments. Decrease in bulk density in mole plot was due to presence of macropores developed by the moling. The highest reduction in bulk density was recorded under treatment S_1D_1: 2m S x 0.4 m D followed by S1D2: 2m S x 0.5 m D at both the depth during the couple of years. Under various treatments the lowest changes were observed in case of S_4D_3: 8m S x 0.6 m and D S_4D_2: 8m S x 0.5 m D treatments. The similar findings on bulk density due to mole drainage in Vertisols were also reported by Theobald (1963), Singh (1978), Jha and Koga (1995) and Ramana Rao *et al.* (2009).

Conclusions:

Mole drains can be formed in vertisols at different treatment when the average soil moisture content is between 22.7 - 26 % and average clay content is 52.31% at moling depth. Field capacity of mole plough for mole drains formation recorded highest under S_4D_1 (mole drains at the spacing of 8 m on the depth of 0.4 m) and lowest under S_1D_3 (mole drains at the spacing of 4 m on the depth of 0.6 m). Mole drain with S_1D_1 (spacing of 2 m at the depth 0.4 m) was found better in comparison with other mole drains spacing and depth as well as the control. Effect of mole drainage on the growth parameters and productivity of soybean in various mole drains treatments was found better in comparison with control (No mole drain).

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