Current World Environment Vol. **9**(2), 387-393 (2014)

Effectiveness of Mole Drains for Soybean Crop in Temporary Waterlogged Vertisols of Madhya Pradesh

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http://dx.doi.org/10.12944/CWE.9.2.19

(Received: March 09, 2014; Accepted: June 19, 2014)

ABSTRACT

Field experiments were conducted during kharif 2010 to 2011 for sustaining productivity of soybean through mole drainage technology in temporary waterlogged vertisols at farmer's fields in Hoshangabad district of Madhya Pradesh.The mole drain spacing selected includes 2, 4, 6 and 8 m and these drains were formed at an average depth of 0.4, 0.5 and 0.6 m from ground surface under a split plot designed experiment with 3 replications.Under various treatment combinations, the plant height, number of branches per plant, root nodules per plant, dry weight of root nodules per plant and yield of soybean crop are highest in 2 m drain spacing followed by 4m, 6m, 8m and control plot in all selected depths.The highest B: C ratio was recorded under S_2D_1 followed by S_3D_1, while the lowest net return was recorded under S_4D_3 in the year 2010-11. In 2011-12 and in pooled data analysis the B:C ratio was recorded higher under S_1D_1 followed by S_1D_2 respectively. The lowest B: C ratio under mole drain treatment was found under control plot.Pipe less drainage (mole) technology for vertisols of Madhya Pradesh is found better in view of soybean productivity.

Key words : Drainage, Drain spacing, Drain depth ,Mole drains, Soybean, Vertisols.

INTRODUCTION

Mole drainage is a temporary method of drainage. There maximum life of Mole drainage is 10- 30 years. Mole drainage alone, on the hand, usually offers a good solution to drainage problems in most clayed soils. Soil loosening by deep ploughing or subsoilingto improve hydraulic conductivity is only justified in situation where mole drainage would be unsuccessful. Drainage is a big problem in vertisolsspecially in the area having rainfall. There are several drainage technologies available in these area but low cost semi-permanent structure mole drains may be a best option. Mole drains are pipeless drains that are formed a 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 fro m 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.

Several researchers, mostly outside India have studied the influence of mole drainage on crop production. Eggelsmenn (1987) reported an increase in crop yield from 20 to over 100% due to pipeless drainage. Mueller and Schindler (1992) also found a significant increase in crop yields due to pipeless drainage over 10 years. Jha and Koga (1995) examined the impact of pipeless drainage on soil properties and on soybean growth in Bangkok soils. The effects of pipeless drainage on soil physical and chemical properties were found to be very significant : basic infiltration rate increased by about 2.7 fold, porosity increased by 14% at 25 cm depth and by 19% at 40 cm depth, soil aeration improved markedly, saturated hydraulic conductivity increased by 34 fold at 25 cm depth and by 61 fold at 40 cm depth, and pipeless drains with liming showed along-lasting improvement in soil pH and EC in the lower soil profile. Because of these improvements in the soil properties it was found that the soyabean crop responded very well to pipe less drainage. There was about 46% increase in grain yield and 118% increase in the dry matter per plant. K.V.Ramana Rao *et.al.* (2009) a 4- year (2004-2009) field experiment was carried out at Central Institute of Agricultural Engineering (CIAE), Bhopal feasibility of mole drainage for draining excess rain water in Vertisols. A 56 PS wheel tractor was used in the drawing of mole drains at 2, 4 and 6 m spacings and at a constant depth of 0.60 m at grade of 0.8 % .The soil moisture content was 22.5% at moling depth. The quantity of drained water from the plots under each of drain spacing was monitored using water meter. The drained area between each was 480 m^2, 960 m^2 and 1080 m^2 for 2, 4 and 6 m drain spacings respectively. The crop yields increased by about 50% in the mole drained plots as compared to the control. The field capacity of mole plough during formation of mole drains at 2,4 and 6 m drain spacing were 0.14,0.28 and 0.42 ha/h respectively while the cost per ha for construction of mole drains at 2,4 and 6 m drain spacing were Rs 3200,Rs 1800 and Rs 1200 respectively.

Considering the above aspects an attempt has been made under the present study to assess effectiveness of mole drains for soybean crop in temporary waterlogged vertisols of Madhya Pradesh.

MATERIALS AND METHODS

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°37'30" to 22°38'10" N latitude and 77°39'30" to 77°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 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 1.The mole drains installed 4 spacing (2,4,6 and 8m spacing) at 3 depths (0.4,0.5 and 0.6 m depth) under a split plot designed experiment with 3 replications.

Measurement of different growth characters and yield of soybean Plant height

Plant height at 30, 45 and 60 days after sowing and at harvest stage was recorded. In each net plot five plants were selected randomly and tagged for periodic observation. The height (cm) was recorded at 30, 45, 60 DAS and at harvest stage of the crop in all the plots. It was measured from the ground surface to the main stem apex.

No. of Branches per plant

Number of branches was recorded at 30, 45, 60 DAS and at harvest stage of the crop in all the plots. It was measured on five plants which were selected randomly and tagged.

Root Studies

Root is a major part of the plant which provides anchoring and active participation in nutrient, moisture uptake and play effective role in fixation of atmospheric nitrogen. For root studies, observation on root length and root dry weight were recorded and analysed statistically.

Root Length

Five plants were selected randomly from each plot and the length of root was taken in cm.

The observation on root length was taken at 45 and 60 days after sowing.

Root nodules per plant

As the root nodules play a vital role in the productivity, Five random plants dug up randomly in each plot and the root was washed for counting the number of nodules. This study was done at 45 and 60 days after sowing.

Table 1:Details of treatment combination for mole drains spacing and depths

Symbol	Treatments detail for Soybean crop
T0	S_0D_0 –Control
T1	S_1D_1 (Mole spacing 2 m + depth 0.4 m)
T2	S_1D_2 (Mole spacing 2 m + depth 0.5 m)
T3	S_1D_3 (Mole spacing 2 m + depth 0.6 m)
T4	S_2D_1 (Mole spacing 4 m + depth 0.4 m)
T5	S_2D_2 (Mole spacing 4 m + depth 0.5 m)
T6	S_2D_3 (Mole spacing 4 m + depth 0.6 m)
T7	S_3D_1 (Mole spacing 6 m + depth 0.4 m)
T8	S_3D_2 (Mole spacing 6 m + depth 0.5 m)
T9	S_3D_3 (Mole spacing 6 m + depth 0.6 m)
T10	S_4D_1 (Mole spacing 8 m + depth 0.4 m)
T11	S_4D_2 (Mole spacing 8 m + depth 0.5 m)
T12	S_4D_3 (Mole spacing 8 m + depth 0.6 m)

Dry weight of root nodules per plant

The dry weight of nodules was taken after oven drying at 70 ± 1 °C for 48 hours. This was also done at 45 and 60 DAS

Seed yield

The soybean plants were harvested net plot-wise and then threshed after the sun drying. The seed yield of each net plot was recorded then converted in to kg/ha.

Benefit: cost ratio (B: C ratio)

It was calculated by dividing the gross return under a treatment by the cost of cultivation under the same treatment and is expressed as returns per rupee invested.

RESULTS AND DISCUSSION

Plant height under various mole drain treatments

The data on plant height, which is an important index of plant growth, were recorded periodically at an interval of 15 days beginning from 30 DAS and analyzed statistically and are presented in Table 2. The interactive effect of mole drain spacings and mole drain depths were found significant at 45 DAS, 60 DAS and at harvest stages

Table 2:Effect of interaction S X D on plant height of soybean.

Treat-ment	30 DAS			45 DAS			60 DAS			At harvest		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
S_0D_0	14.2	14.3	14.3	36.1	36.7	36.4	44.9	45.3	45.1	46.28	46.66	46.47
S_1D_1	23.7	24.1	23.9	55.3	54.6	54.9	67.0	66.3	66.7	69.01	68.32	68.67
S_1D_2	23.9	22.3	23.1	53.5	53.8	53.7	64.8	65.1	65.0	66.78	67.05	66.92
S_1D_3	21.5	21.2	21.4	53.2	52.2	52.7	64.8	64.0	64.7	66.74	65.95	66.35
S_2D_1	21.2	21.1	21.1	51.4	51.8	51.6	63.6	63.5	63.5	65.47	65.37	65.42
S_2D_2	20.9	20.7	20.8	50.4	51.2	50.8	63.4	62.7	63.1	65.34	64.55	64.94
S_2D_3	20.9	20.4	20.6	49.3	49.7	49.5	64.2	62.1	63.2	66.13	64.00	65.06
S_3D_1	19.7	20.5	20.1	50.4	49.8	50.1	64.0	64.6	64.3	65.92	63.17	64.55
S_3D_2	20.3	19.4	19.8	49.9	47.5	48.7	59.1	59.0	59.1	60.91	59.74	60.32
S_3D_3	17.7	15.6	16.7	40.2	40.3	40.3	51.4	50.3	50.9	52.98	51.77	52.38
S_4D_1	17.8	17.0	17.4	38.6	37.9	38.3	50.3	51.3	50.8	51.81	51.19	51.50
S_4D_2	17.7	16.4	17.0	40.0	38.6	39.3	47.3	48.7	48.0	50.30	48.25	49.28
S_4D_3	15.4	13.7	14.6	37.1	35.9	36.5	46.5	46.1	46.3	47.86	48.12	47.99
SEm=	0.47	0.61	0.42	0.91	1.28	0.89	1.66	2.10	1.48	1.69	1.29	1.28
$CD_{(5\%)}$	NS	NS	1.29	2.82	NS	2.75	5.13	NS	4.57	5.20	3.98	3.94

of soybean in year 2010-11 and pooled data analysis however it was not found statistically significant at 45 DAS and 60 DAS during the year 2011-12. Maximum plant height was recorded in the case of combination S_1D_1 (mole drains at the spacing of 2 m on the depth of 0.4 m) followed by S_1D_2 (mole drains at the spacing of 2 m on the depth of 0.5 m) while it was recorded significantly lowest under S_4D_3 (mole drains at the spacing of 8 m on the depth of 0.6 m) in all the growth stages during both the years. Jha and Koga (1995), Ramana Rao *et.al.(*2005) and Kolekar et.al. (2011) also corroborated the same findings due to pipeless drainage.

Table 3:Effect of interaction S X D on No. of branch per plant of soybean at different growth and at harvest stages

	30 DAS			45 DAS			60 DAS			At harvest		
Treat-ment	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
S0D0	1.57	1.60	1.58	2.03	2.07	2.05	3.00	2.90	2.95	4.03	3.83	3.93
S1D1	2.37	2.30	2.33	3.37	3.27	3.32	5.40	5.10	5.25	5.83	6.13	5.98
S1D2	2.23	2.27	2.25	3.17	3.23	3.20	5.23	5.37	5.30	5.80	5.63	5.72
S1D3	2.23	2.20	2.22	3.07	3.10	3.08	4.73	4.77	4.60	5.53	5.43	5.48
S2D1	2.13	2.10	2.12	3.10	3.07	3.08	4.70	4.30	4.35	5.33	5.37	5.35
S2D2	2.07	2.00	2.03	3.07	3.10	3.08	4.13	4.23	4.18	5.37	5.27	5.32
S2D3	2.00	1.97	1.98	3.03	3.07	3.05	4.13	4.20	4.17	5.33	5.07	5.20
S3D1	1.83	1.90	1.87	3.07	2.97	3.02	4.07	4.10	4.08	5.30	5.27	5.28
S3D2	1.83	1.87	1.85	2.57	2.57	2.57	3.97	4.13	4.05	5.10	5.17	5.13
S3D3	1.80	1.87	1.83	2.47	2.50	2.48	3.87	3.60	3.73	4.77	4.60	4.68
S4D1	1.77	1.70	1.73	2.37	2.30	2.33	4.50	4.77	4.63	5.67	5.37	5.52
S4D2	1.67	1.70	1.68	2.23	2.27	2.25	3.53	3.27	3.40	4.53	4.07	4.30
S4D3	1.60	1.63	1.62	2.23	2.20	2.22	3.03	2.97	3.00	4.10	3.83	3.97
SEm=	0.07	0.13	0.06	0.18	0.17	0.14	0.17	0.24	0.18	0.17	0.12	0.11
CD(5%)	NS	NS	NS	NS	NS	NS	0.53	0.73	0.55	0.52	0.37	0.33

Table 4:Effect of interaction S X D on root length of soybean at 45 and 60 DAS

	45 DAS			60 DAS		
Treatment	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
S_0D_0	10.80	9.44	10.12	12.26	13.47	12.87
S_1D_1	19.29	17.16	18.23	24.34	27.52	25.93
S_1D_2	19.48	17.65	18.57	23.77	27.85	25.81
S_1D_3	17.44	16.51	16.98	23.48	26.87	25.17
S_2D_1	17.62	16.66	17.14	21.18	25.10	23.14
S_2D_2	18.31	16.36	17.33	19.09	24.38	21.74
S_2D_3	16.68	16.10	16.39	20.42	24.47	22.45
S_3D_1	15.78	15.26	15.52	21.23	23.88	22.56
S_3D_2	14.30	14.37	14.34	19.21	21.31	20.26
S_3D_3	14.10	10.40	12.25	14.31	15.00	14.66
S_4D_1	15.83	14.96	15.40	14.41	16.22	15.32
S_4D_2	11.12	10.57	10.85	13.24	14.14	13.69
S_4D_3	11.05	10.20	10.62	13.81	13.97	13.89
SEm=	0.70	0.85	0.46	0.98	1.15	0.59
$CD_{(5\%)}$	2.16	2.62	1.43	3.03	3.55	1.83

No. of branches per plant under various mole drain treatments

The number of branches per plant increased as the age of the crop advanced. and presented in Table 3 for different growth and at harvest stages of soybean. In case of interaction effects, maximum number of branches per plant at almost all the stages of soybean was recorded under S_1D_1 (mole drains at the spacing of 2 m on the depth of 0.4 m) followed by S_1D_2 (mole drains at the spacing of 2 m on the depth of 0.5 m). Whereas, the minimum values were noticed under the treatments S_4D_3 (mole drains at

Table 5:Effect of interaction S X D on Number of root nodules per plant of soybean at 45 and 60 DAS

Treatment	45 DAS			60 DAS		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
S0D0	9.83	9.36	9.59	18.89	19.42	19.16
S1D1	19.40	19.15	19.27	36.82	35.99	36.41
S1D2	19.18	19.62	19.40	33.14	37.51	35.33
S1D3	18.40	18.54	18.47	35.19	34.79	34.99
S2D1	18.89	18.70	18.79	34.93	32.33	33.63
S2D2	17.35	18.41	17.88	33.54	33.91	33.73
S2D3	15.42	18.13	16.78	32.34	32.36	32.35
S3D1	15.18	15.00	15.09	27.83	28.53	28.18
S3D2	13.81	13.63	13.72	27.35	27.15	27.25
S3D3	12.98	12.96	12.97	23.81	23.08	23.44
S4D1	14.30	13.77	14.04	23.50	23.85	23.67
S4D2	11.58	10.73	11.16	20.17	22.95	21.56
S4D3	10.11	10.22	10.16	19.52	19.86	19.69
SEm=	0.92	1.10	0.70	1.97	1.57	1.05
CD (5%)	NS	NS	NS	NS	NS	NS

Table 6:Effect of interaction S X D on dry weight of root nodules per plant of soybean at different growth stages (mg)

Treatment	45 DAS			60 DAS		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
S0D0	147.47	149.90	148.68	270.60	267.10	268.85
S1D1	260.33	268.23	264.28	450.44	450.50	450.47
S1D2	260.87	261.21	261.04	432.67	423.59	428.13
S1D3	263.13	251.65	257.39	407.93	403.64	405.78
S2D1	237.72	260.83	249.27	415.76	410.61	413.19
S2D2	236.24	240.13	238.18	391.03	370.08	380.55
S2D3	215.22	222.81	219.02	380.09	413.52	396.80
S3D1	209.25	204.39	206.82	404.00	326.43	365.21
S3D2	184.65	231.53	208.09	311.95	370.95	341.45
S3D3	201.99	178.73	190.36	327.93	251.54	289.74
S4D1	182.03	174.93	178.48	281.10	343.39	312.24
S4D2	142.57	154.23	148.40	302.21	270.64	286.43
S4D3	141.03	156.29	148.66	302.07	272.27	287.17
SEm=	6.84	7.78	4.35	15.07	15.35	8.76
CD(5%)	21.07	23.97	13.41	46.42	47.29	27.00

Table 7:Seed and benefit cost ratio of various mole drain treatment

Treatment	Seed yield (kg/ha)			B: C ratio		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
S_0D_0: Control	888.19	805.46	846.83	1.04	1.12	1.08
S_1D_1: 2m S X 0.4 m D	1630.68	1650.63	1640.66	1.52	2.32	1.92
S_1D_2: 2m S X 0.5 m D	1621.58	1645.97	1633.77	1.50	2.31	1.91
S_1D_3: 2m S X 0.6 m D	1572.49	1536.90	1554.70	1.43	2.16	1.79
S_2D_1: 4m S X 0.4 m D	1566.79	1502.15	1534.47	1.62	2.10	1.86
S_2D_2: 4m S X 0.5 m D	1541.18	1425.79	1483.48	1.59	2.00	1.79
S_2D_3: 4m S X 0.6 m D	1479.30	1482.15	1480.73	1.52	2.08	1.80
S_3D_1: 6m S X 0.4 m D	1482.30	1453.55	1467.93	1.61	2.05	1.83
S_3D_2: 6m S X 0.5 m D	1478.51	1432.17	1455.34	1.59	2.01	1.80
S_3D_3: 6m S X 0.6 m D	1382.01	1284.60	1333.31	1.48	1.80	1.64
S_4D_1: 8m S X 0.4 m D	1078.59	1077.58	1078.08	1.18	1.51	1.35
S_4D_2: 8m S X 0.5 m D	1036.99	1035.77	1036.38	1.14	1.45	1.30
S_4D_3: 8m S X 0.6 m D	1034.12	1016.80	1025.46	1.11	1.42	1.27
SEm=	15.87	23.59	11.41	0.02	0.03	0.02
$CD_{(5\%)}$	48.91	72.70	35.18	NS	0.10	0.05

the spacing of 8 m on the depth of 0.6 m) and S_0D_0: Control. Similar findings were found by Ramana Rao *et.al. (*2009) due to pipeless drainage in soybean crop .

Root length under various mole drain treatments

The root length under different treatments at 45 and 60 DAS is presented in Table 4.The maximum root length was noticed under combination S_1D_1 (mole drains at the spacing of 2 m on the depth of 0.4 m) followed by S_1D_2 (mole drains at the spacing of 2 m on the depth of 0.5 m) at both the stages. The significantly least values were recorded under S_4D_3 (mole drains at the spacing of 8 m on the depth of 0.6 m) at 45 DAS and S_4D_2 (mole drains at the spacing of 8 m on the depth of 0.5 m) at 60 DAS. The values of root length were recorded lowest under the treatment S_0D_0: Control. Similar findings were obtained Jha and Koga (1995) due to pipeless drainage in soybean crop.

Number of root nodules per plant under various mole drain treatments

The root nodules are responsible for the fixation of atmospheric nitrogen in the soil. The data on number of root nodules per plant were taken at 45 DAS and 60 DAS and analyzed statistically and presented in Table 5. Interactive effects of spacing and depth of mole drains were found significant in the year 2011-12 and pooled analysis only at 60 DAS and treatment S_1D_1 (mole drains at the spacing of 2 m on the depth of 0.4 m) produced maximum root nodules per plant followed by S_1D_3 (mole drains at the spacing of 2 m on the depth of 0.6 m) in 2010-11 and S_1D_2 (mole drains at the spacing of 2 m on the depth of 0.5 m) during 2011-12 and pooled data analysis. These treatments were significantly superior to control (no mole drains) which produced lowest number of root nodules per plant. Similar findings were obtained Jha and Koga (1995) due to pipeless drainage in soybean crop.

Dry weight of root nodules per plant under various mole drain treatments

The data on Dry weight of root nodules per plantunder various mole drain treatments were taken at 45 DAS and 60 DAS and analyzed statistically and presented in Table 6. Interaction of spacing and depth of mole drains was found significant in both the years and in pooled analysis of data at 45 DAS while at 60 DAS it was found significant in the year 2011-12 and pooled data analysis. S_1D_1 (mole drains at the spacing of 2 m on the depth of 0.4 m) and S_1D_2 (mole drains at the spacing of 2 m on the depth of 0.5 m) produced maximum dry weight of nodules per plant during both the years as well as in pooled data; however they were statistically at par with each other. Minimum values were observed under S_4D_3 (mole drains at the spacing of 8 m on the depth of 0.6 m) and control (no mole drains).

Seed yields and B:C ratio under various mole drain treatments

Seed yields and B:C ratio under various mole drain treatment are presented in Table 7.The maximum seed yields was recorded under S_1D_1 (mole drains at the spacing of 2 m on the depth of 0.4 m) followed by S_1D_2 (mole drains at the spacing of 2 m on the depth of 0.5 m) and S_1D_3 (mole drains at the spacing of 2 m on the depth of 0.6 m) during boththe year and pooled data as well. The highest productivity of 16.4 q/ha observed in the treatments with mole drains at 2m spacing with 0.4m depth while it was found lowest under control (8.4 q/ha) followed by S_4D_3 (mole drains at the spacing of 8 m on the depth of 0.6 m) treatment. The highest B: C ratio was recorded under S_2D_1 followed by S_3D_1, while the lowest net return was recorded under S_4D_3 in the year 2010-11. In 2011-12 and in pooled data analysis the B:C ratio was recorded higher under S_1D_1 followed by S_1D_2 respectively. The lowest B: C ratio under mole drain treatment was found under control plot followed by S_4D_3in pooled data analysis. Under the absolute control the values were found to be lowest as compared to all the treatments. Jha and Koga (1995 and Ramana Rao *et.al. (*2009 & 2012) also reported an increase in crop yield due to pipeless drainage in Vertisol.

CONCLUSIONS

Under actual field conditions studies on mole drains were taken up in Hoshangabad district of MP. Mole drain formation has bearing on the crop performance, which is also influenced by mole drain spacing and drain depth. In the present study plant height, number of branches per plant, root nodules per plant , dry weight of root nodules per plant and yield of soybean under different treatments were monitored. Mole drain with S_1D_1 (spacing of 2 m at the depth 0.4 m) was found better in comparison with other spacing and depth as well as the control. B:C ratio of mole drain with S_2D_1 (spacing of 4 m at the depth 0.4 m) & S_1D_1 (spacing of 2 m at the depth 0.4 m) were found most profitable during 1st year and 2nd year of experiment respectively. Effect of mole drainage technology on the yield & growth parameter of soybean under waterlogged conditions was found better. Pipe less drainage (mole) technology for vertisols of Madhya Pradesh is found better in view of soybean productivity.

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