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Measurement of dew at the Central Agricultural Meteorological Observatory, Poona

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1. General

Ramdas and Katti (1934) have shown how the soil absorbs and gives up water vapour from the atmosphere in the dry season. During the day, the soil dries out readily, but at night it is able to absorb large amounts of water from the air layer resting upon it. They have estimated the average water content of the soil to be 7·8 per cent in the morning and this goes down to nearly 3·8 per cent in the afternoon. This process of absorption by the soil surface has been designated as 'invisible condensation' to distinguish it from the well known phenomenon of dew. During the afternoon and night, when invisible condensation is in progress, the vapour pressure naturally increases with height, indicating a downward flow of moisture towards the ground. During the earlier part of the day, when moisture is being lost by the soil, the vapour pressure decreases with height indicating an upward flow of moisture from the surface of the ground.

Besides 'invisible condensation', which sets a limit to the continuous loss of moisture from the ground, during clear calm nights, the surfaces of the ground and of objects near the ground which are exposed to the sky as well as the air layers near the ground, lose heat as a result of radiation exchange. When the cooling is sufficient to bring down the temperature below the saturation temperature of the air which surrounds them, water condenses and deposits on them as dew. It is a form of precipitation that cannot be measured with the raingauge and is one of the important sources of moisture to the soil in plant growth during times of drought and in arid or semi-arid regions. Dew is also responsible for the spread of many plant diseases.

2. The Duvdevani dew gauge

There has been no simple technique for measuing dew, and the usual methods are by direct weighing of the deposit collected on a surface. This is elaborate and cumbersome. However, the Duvdevani dew gauge (Duvdevani 1947) is a simple instrument and facilitates estimation of dew even at various levels. A standardised block of wood having a flat non-hygroscopic surface of poor heat conduction, coated with a red paint which favours the retention of dew deposited on it, is exposed and the appearance of the dew formed on this exposed surface is related to the amount collected. The amount of dew is usually expressed in kgm per square metre of exposed surface or in mm of dew, 1 mm of dew equalling 10 gm of dew per 100 sq. cm.

The dew gauge is exposed at about sunset and the size, form and distribution of the dew deposited in the gauge is observed at about sunrise. This appearance is compared with a set of standard photographs of each dew type. These photographs bear the dew scales 1 to 8, each number bearing its equivalent in mm of dew.

3. Amount of dew and number of dew days at Poona

Dew fall was very intensively studied at the Central Agricultural Meteorological Observatory at Poona with the Duvdevani dew gauges during the clear seasons from

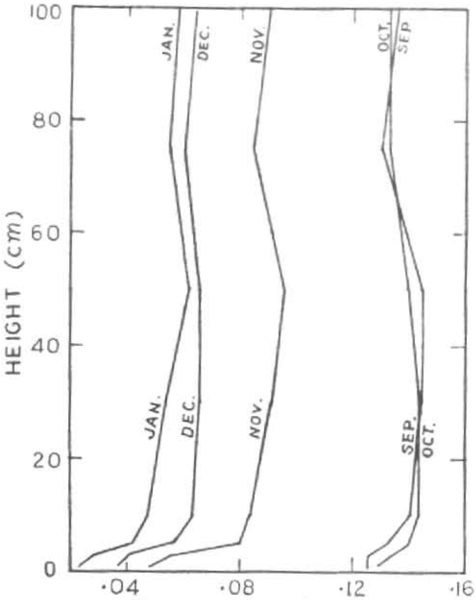

Fig. 1. Mean dew amount per dew day at different levels for different months

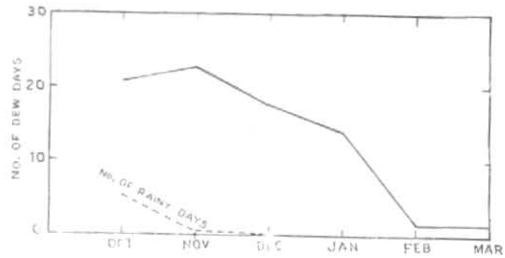

Fig. 2. Mean number of dew days on different months at Poona

1952 to 1955. These dew gauges were exposed at heights of 1, 3, 5, 10, 30, 50, 75, 100, 200, 600 and 1000 cm above ground during the non-monsoon months from September to June. Table 1 gives the number of days on which the dew was observed and the mean amount of dew collected in mm of water in each month at each level for the period September 1952 to May 1956. Fig. 1 shows the mean dew amount on each day during the months of September to January at different levels. The average number of dew days in each month are shown in Fig. 2. The number of days of dew and the amount collected are negligibly small from February to June; July to September are rainy on many nights.

It is observed from the data collected at Poona for the last 4 years that during the season October to January when dew occurs frequently at Poona, the largest average amount occurs in October, being of the order of about 3 mm; it is about 2 mm in November, 1 mm in December and only about 0·75 mm in January. However, the amount collected in each month varies appreciably from year to year. For example, during October it is between 2 to 4 mm, 1 to 3 mm in November, almost nil to about 1·5 mm in December and 0·3 to 2 mm in January.

The average daily dew fall in September and October is nearly the same, *viz.*, about 0·145 mm and is larger than that in any other month. The average daily fall decreases from November and the lowest value is of the order of 0·03 to 0·05 mm from January onwards.

The average number of dew days is almost the same in October and November (21 and 23 days) and it decreases with the advance of the season. The number of dew days varies appreciably in each month from year to year from November onwards. For example, it varies from 16 to 30 in November, 5 to 27 in December and 4 to 29 in January. From February onwards, dew fall is rare at Poona,

4. Variation of the amount of dew with height

An examination of the dew deposited at different levels shows some interesting features. The amount is least very near the ground and increases with height. The amount increases appreciably from 1 cm above ground to 5 cm, above which it increases gradually reaching a maximum value at the 50-cm level. It falls above this level upto 75 cm. There is a slight rise above this level and from Table 1, it appears that there is a secondary maximum in the amount of dew between 1 and 2 metres during the months September to January.

TABLE 1

Total dew amount (mm) for each month at Poona

	No. of dew nights	Centimetre							Metre				No dew	Rainy nights
		1	3	5	10	30	50	75	1	2	6	11·5		
							SEPTEMBER							
1952	3	0·185	0·185	0·280	0·350	0·380	0·420	0·350	0·390	0·420	0·500	0·540		
1953	2	0·390	0·390	0·350	0·350	0·350	0·350	0·310	0·310	0·310	0·250	0·210		
1954	1	0·070	0·070	0·070	0·070	0·070	0·070	0·070	0·070	0·100	0·100	0·100		
1955	2	0·360	0·360	0·360	0·360	0·360	0·320	0·320	0·320	0·360	0·185	0·185		
Mean	2	0·126	0·126	0·133	C·141	0·145	0·145	0·131	0·136	0·149	0·127	0·131		
							OCTOBER							
1952	20	1·975	2·350	2·710	2·685	2·645	2·780	2·695	2·715	2·680	2·020	2·145	4	7
1953	22	1·850	1·850	1·895	1·855	2·025	1·920	1·750	1·740	1·820	1·710	1·655	5	4
1954	22	2·545	2·545	2·695	2·795	2·820	2·775	2·525	2·550	2·590	2·520	2·450	9	0
1955	19	4·355	4·355	4·315	4·315	4·355	4·190	4·080	4·080	4·010	4·050	3·980	2	10
Mean	21	0·129	0·134	0·140	0·140	0·143	0·140	0·133	0·133	0·134	0·124	0·123		
							NOVEMBER							
1952	30	0·360	0·935	2·170	2·475	2·600	2·975	2·445	2·520	2·405	2·025	1·915	0	0
1953	16	0·780	0·780	1·515	1·235	1·555	1·350	1·440	1·445	1·595	1·540	1·540	14	0
1954	18	0·605	0·625	0·860	0·905	0·980	0·980	0·765	0·755	0·690	0·655	0·635	12	0
1955	27	2·620	2·680	2·855	2·910	3·205	3·395	3·115	3·445	3·280	2·750	2·485	1	2
Mean	23	0·048	0·055	0·080	0·083	0·092	0·096	0·085	0·090	0·087	0·077	0·072	8	0
							DECEMBER							
1952	22	0·240	0·395	1·145	1·265	1·420	1·415	1·010	1·165	1·115	0·725	0·715	9	0
1953	5	0	0	0·090	0·070	0·070	0·095	0·035	0·105	0·165	0·185	0·185	26	0
1954	17	1·100	1·125	1·355	1·460	1·550	1·610	1·345	1·475	1·420	1·200	1·225	14	0
1955	27	1·340	1·425	1·475	1·700	1·645	1·580	1·850	1·830	1·820	1·400	1·345	4	0
Mean	18	0·037	0·041	0·057	0·063	0·066	0·066	0·060	0·064	0·064	0·047	0·049	13	0
							JANUARY							
1953	14	0·065	0·135	0·605	0·640	0·710	0·800	0·555	0·630	0·585	0·325	0·325	17	0
1954	4	0·075	0·180	0·215	0·205	0·315	0·325	0·160	0·235	0·235	0·345	0·285	27	0
1955	9	0·270	0·315	0·345	0·355	0·385	0·395	0·410	0·440	0·400	0·370	0·345	21	0
1956	29	0·850	0·950	1·165	1·410	1·615	1·960	1·930	1·960	1·810	1·605	1·530	2	0
Mean	14	0·023	0·028	0·042	0·047	0·054	0·062	0·055	0·058	0·054	0·047	0·044	17	0

TABLE 1 *(contd.)*

	No. of dew nights	Centimetre 1	3	5	10	30	50	75	Metre 1	2	6	11·5	No. dew	Rainy nights
							FEBRUARY							
1953	0	0	0	0	0	0	0	0	0	0	0	0	28	0
1954	1	0·025	0·025	0·025	0·025	0·045	0·045	0·025	0·045	0·045	0·045	0·045	27	0
1955	2	0·225	0·225	0·225	0·025	0·255	0·255	0·225	0·225	0·225	0·225	0·225	26	0
1956	3	0·045	0·045	0·045	0·045	0·045	0·065	0·065	0·065	0·065	0·065	0·065	26	0
Mean	2	0·049	0·049	0·049	0·049	0·049	0·061	0·053	0·056	0·056	0·056	0·056	26	0
							MARCH							
1953	3	0·055	0·055	0·070	0·045	0·045	0·080	0·065	0·090	0·090	0·090	0·090	28	0
1954	2	0·070	0·070	0·145	0·115	0·115	0·145	0·070	0·115	0·115	0·145	0·145	29	0
1955	0	0	0	0	0	0	0	0	0·.70	0	0	0	31	0
1956	1	0	0	0	0	0·010	0·025	0·025	0	0·025	0·025	0·025	30	0
Mean	2	0·021	0·021	0·036	0·027	0·028	0·042	0·027	0·034	0·038	0·043	0·043	29	0
							APRIL							
1953	8	0·255	0·205	0·290	0·320	0·310	0·400	0·185	0·225	0·100	0·025	0·045	22	0
							(No dew in 1954, 1955 and 1956)							
							MAY							
1953	11	0·255	0·260	0·395	0·420	0·395	0·490	0·145	0·155	0·140	0·160	0·160	20	0
							(No dew in 1954, 1955 and 1956)							
							JUNE							
1953	1	0·045	0·045	0·045	0·045	0·025	0·025	0·010	0·010	0·010	0·010	0·010		
							(No dew in 1954 and 1955)							

The difference in mm between the amounts collected daily near the ground and at the 50-cm level in each month is given below—

Sep	Oct	Nov	Dec	Jan
0·019	0·014	0·048	0·029	0·039

The difference is least in September—October and largest in November. Ramdas and Katti (1934) have shown that during the night the soil absorbs moisture and the vapour pressure increases with height. This is presumably the reason for the observed variation of the amount of dew collected in the levels near the ground. The difference between the amounts at 1 cm and 50 cm is lowest in September—October, for, during these months the amount of moisture present in the soil is the largest and, therefore, the absorption of moisture will be the least. The lower value from December onwards is because the air is drier and the duration of deposition of dew and amount of dew formed are smaller.

It is interesting to note the secondary minimum in the amount of dew collected at the 75-cm level. It appears to be a definite feature as it is observed in all the months. It is seen from Table 1, that the one day in March 1956 was critical, for dew formed only between 30 and 75 cm and 2 metres and above.

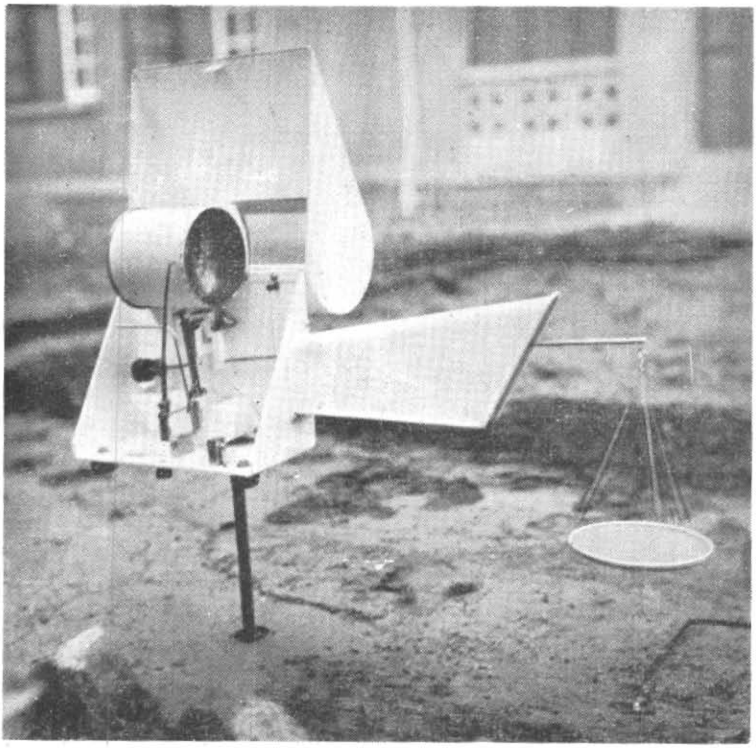

Fig. 3

The two layers of low dew deposition, *viz.*, one near the ground and the other at a height of about 75 cm and the two maxima at about 50 and 100 cm, seem to indicate a lamination of layers of dew deposition. From the micro-climatic observations in the open at Poona at the minimum temperature epoch (0700 L.T.), it is seen that the saturation deficit also seems to indicate a similar variation with height as given below for November (1953-55).

Surface	2·5	7·5	15	30	60	90	120	180	240	300
1·4	1·4	1·3	1·2	1·2	1·1	1·2	1·3	1·2	1·2	1·1

Presumably, the absorption of moisture by the soil in the lowest layers and the temperature distribution affect the diffusion of moisture downwards and the observed stratification in the dew formation is the result.

5. Time of occurrence of dew and duration

The Duvdevani dew gauge indicates only the collection of dew early in the morning at the time of observation. It is not possible with this instrument to know the time of beginning of the dew for the rate of settling. It is quite likely that dew formed during the night and evaporated by sunrise. It was possible to obtain information on these points with a Hiltner type of recording dew balance obtained early in 1956 from M/s Wilh. Lambrecht (Germany). This instrument (Fig. 3) consists of a circular nylon hair sieve (100 sq. cm in area) suspended at the beam of a balance by a light aluminium chain. The recording arm is repeatedly geared in order to reduce the difference of height above the ground caused by an inclination of the scale beam, when dew deposits on the sieve. The beam carries a vane dipping in a tray of silicone oil (DC 200) to reduce and damp the oscillations of the sieve and the recording pen.

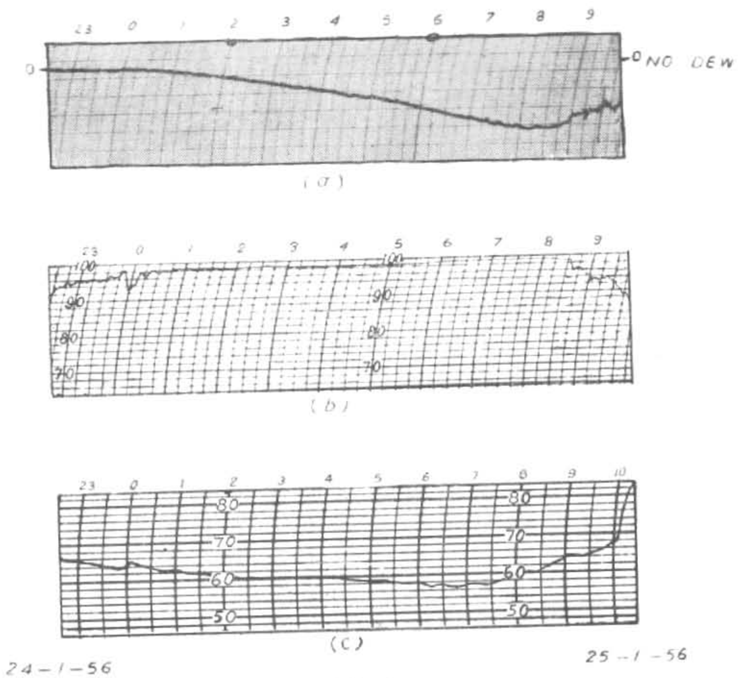

Fig. 4

This instrument was exposed at Poona from January 1956 onwards with the sieve at a height of about 6 inches above ground. The instrument is designed for displacement of about 1 mm of the recording pen for 0·05 gm of dew collected on the sieve. As the daily collection of dew at the minimum temperature epoch during January onwards at Poona observed on the Duvdevani dew gauge was only 0·05 gm or less, the amount of dew collected on the sieve was much less and no record of dew was obtained, though it was observed on the Duvdevani gauge. The instrument was, therefore, adapted to record even small quantities of dew by placing a thin perspex sheet on the sieve. The exposed surface was thus the perspex sheet and not the sieve. With this modification, suitable records were obtained. The extra weight due to the perspex sheet was, however, balanced on the beam with suitable lead weights.

In connection with the experiments on the measurement of dew with the recording dew gauge, one hair hygrograph and one thermograph were also exposed near the perspex collector.

Fig. 4(a) shows the record of dew obtained during the period 2230 IST on 24 January 1956 to 0930 IST on 25 January 1956. It seems that deposition of dew started at about 2230 IST but the rate of deposition increased appreciably from about 0030 IST on 25 January 1956. The maximum rate of deposition was between 0500 to about 0815 IST when it ranged between $2\frac{1}{2}$ to $3\frac{1}{2}$ divisions per hour, *i.e.*, from 0·125 to 0·175 gm per 100 sq. cm. The dew began evaporating from 0830 IST and it completely disappeared by 1015 IST, *i.e.*, what was deposited in $7\frac{1}{2}$ hrs evaporated in about $1\frac{3}{4}$ hrs.

The hygrograph and thermograph charts during the corresponding period are shown in Figs. 4(b) and 4(c). It may be stated again in this connection, that the hygrograph and thermograph were exposed directly to

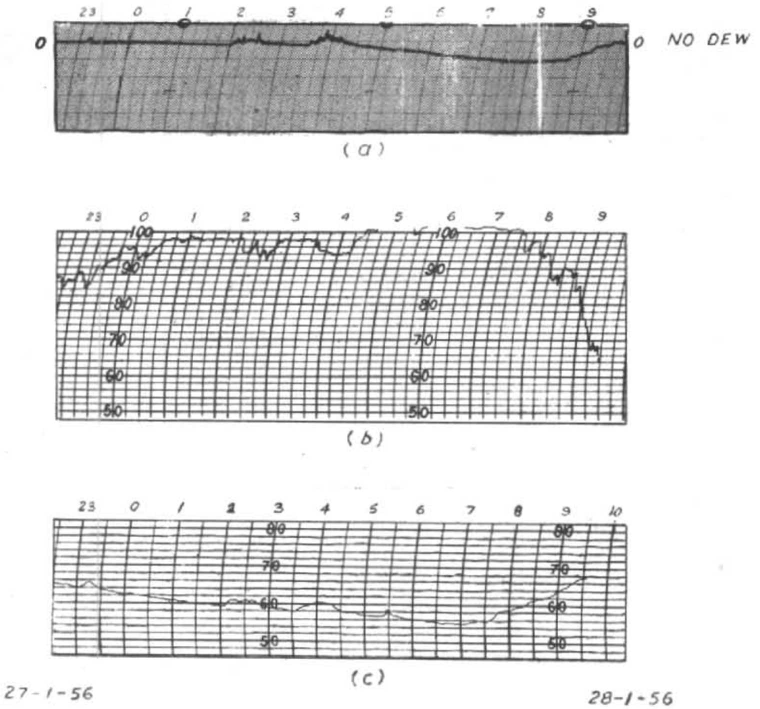

Fig. 5

the atmosphere with the elements almost at the same height as the dew recorder and not in the Stevenson Screen, as usual.

The hygrograph and thermograph charts appear to show changes corresponding to the records of the dew recorder. The values of relative humidity can only be approximate but changes can be considered to be significant. Dew started collecting at a very slow rate from 2230 to about 2400 IST when it evaporated when there was a fall in humidity and a rise in temperature. Dew started collecting continuously from 0015 IST when the relative humidity reached about 98 per cent. The maximum rate of deposition was about 0·175 mm per hour between 0500 and 0600 IST. Though the temperature was rising from about 0700 IST, relative humidity did not fall and there was also no loss of dew by evaporation till 0830 IST when relative humidity began falling rapidly and temperature rose, by nearly 3°, to 60°F.

The records for the period from 2230 IST on 27 January to 0930 IST on 28 January 1956 (Fig. 5), also show some special features. Dew started forming in the recorder at about 0030 IST on 28 January 1956 when the relative humidity was about 98 per cent. However, the small quantity that was collected evaporated at about 0200 IST, when the relative humidity fell by nearly 4 to 6 per cent and temperature rose by nearly 1·5°F. By 0245 IST when the relative humidity rose again to 98 per cent and temperature also fell by 1·5°F, dew began forming again. This evaporated at about 0330 IST due to a fall in relative humidity by 4 per cent and a rise of temperature of 2°F. It again began forming by about 0415 IST when the relative humidity rose to 100 per cent and temperature began falling. The interesting feature of record is the evaporation of the dew twice during the night associated with fall of relative humidity and rise of temperature.

Apparently these were associated with some flow of air as shown by the fluctuations on the dew record caused by the wind on the perspex sheet.

Only a few of the features in the dew deposition at Poona observed during the preliminary trials in January and February with the Hiltner dew recorder have been described. It is hoped that many other characteristics on dew formation may be noticed after collecting the records for a few seasons.

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