

THE EXCHANGE OF MOISTURE BETWEEN PLANT MATERIALS AND THE ATMOSPHERE

BY

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(With four text-figures)

I. INTRODUCTION

RAMDAS and Katti [1934; 1935; 1936] have discussed, in a series of papers, the phenomenon of the diurnal exchange of moisture during the clear season between a dry soil surface when it contains only hygroscopic moisture and the air layers near the ground. They have shown that the soil has its maximum moisture content at the minimum temperature epoch and its minimum moisture content at the maximum temperature epoch. From the morning after sunrise up to the afternoon, the soil surface gives up moisture by evaporation to the air layers above, but thereafter, until the next morning, it desiccates the air layers by re-absorbing almost all the moisture lost. It was also shown that the intensity of this moisture exchange is greatest in the black cotton soil of the Deccan and least in the alluvial soil of the Indo-Gangetic plains.

Much work has been done by various workers* on the hygroscopic properties of textiles like cotton, silk, wool, etc. Mention may be made of the investigations of Wilson and Fuwa [1922] on the absorption of moisture by a variety of materials including some plant materials like tobacco, wheat bread, flour, etc., when exposed to air of different relative humidities. Nazir Ahmad [1933] studied the seasonal variation of the moisture content of bales of cotton stored in godowns. He showed that cotton absorbed moisture during the monsoon season but lost it again during the dry season. Diatlova [1935] found that there is a diurnal variation in the moisture content of grain and straw of spring wheat ready to be harvested, the highest moisture content occurring at 5 A.M. and the lowest moisture content between 1 and 4 P.M.

During the clear season of 1937-38, experiments, similar to those in the case of the soils, were made on the diurnal variation in the moisture content of various plant materials, at the Central Agricultural Meteorological Observatory at Poona. The clear season is characterised by a large diurnal range of

*For references to literature on this subject see Chapter XII of "The absorption of gases and vapours by solids" by J. W. McBain (Routledge and Sons, Ltd., 1932).

temperature, cloudless skies and comparatively low relative humidity during the day. A short note stating some of the results obtained has been published elsewhere [Ramdas and Mallik, 1938]; in the present paper the results are discussed more fully.

II. MATERIALS AND METHODS

The materials used for this study were :

- (a) Black cotton soil of Poona.
- (b) Wheat grain.
- (c) Paddy grain.
- (d) *Bajri* grain.
- (e) *Jowar* grain.
- (f) *Jowar* leaf (cut into pieces).
- (g) *Jowar* leaf (entire).
- (h) *Jowar* stalk (cut into pieces).

All the materials were perfectly dry in the agronomical sense. The specimens were exposed to the atmosphere in small vessels embedded in the soil and their weights determined at desired intervals.

The various conditions to which the specimens were exposed in different experiments were :

- (i) 'Open and exposed to solar radiation'
- (ii) 'Open but shaded from solar radiation' and
- (iii) 'In the Stevenson screen at ground level.'

Two sets of experiments were performed. In one set, the specimens were weighed twice daily at 8 A.M. and 4 P.M. consecutively for six days; this was done with the materials exposed to 'open in sun' and again with specimens exposed inside a Stevenson screen at ground level. In the other set, on some selected days, the diurnal variation in weights of the different materials was studied by taking two-hourly observations. In every case, simultaneous records of temperature and humidity of the air layers were obtained with an Assmann Psychrometer.

III. STATEMENT OF RESULTS

A. *Maximum and minimum moisture content during the period 23rd November 1937 to 28th November 1937*

(a) A set of specimens was exposed to the atmosphere in the sun. The specimens were weighed daily at 8 A.M. and 4 P.M. for six days. The values of atmospheric humidity at the same hours were also calculated from the dry bulb and wet bulb readings of the Assmann Psychrometer. Table I gives the weights in grams of these materials at 8 A.M. and 4 P.M. from the 23rd to the 28th November 1937.

At the bottom of Table I is given the mean weights of the specimens at 8 A.M. and 4 P.M. as well as the difference between the mean 8 A.M. and mean 4 P.M. weights expressed as percentages of the mean values for the whole day. The results are shown graphically in Fig. 1.

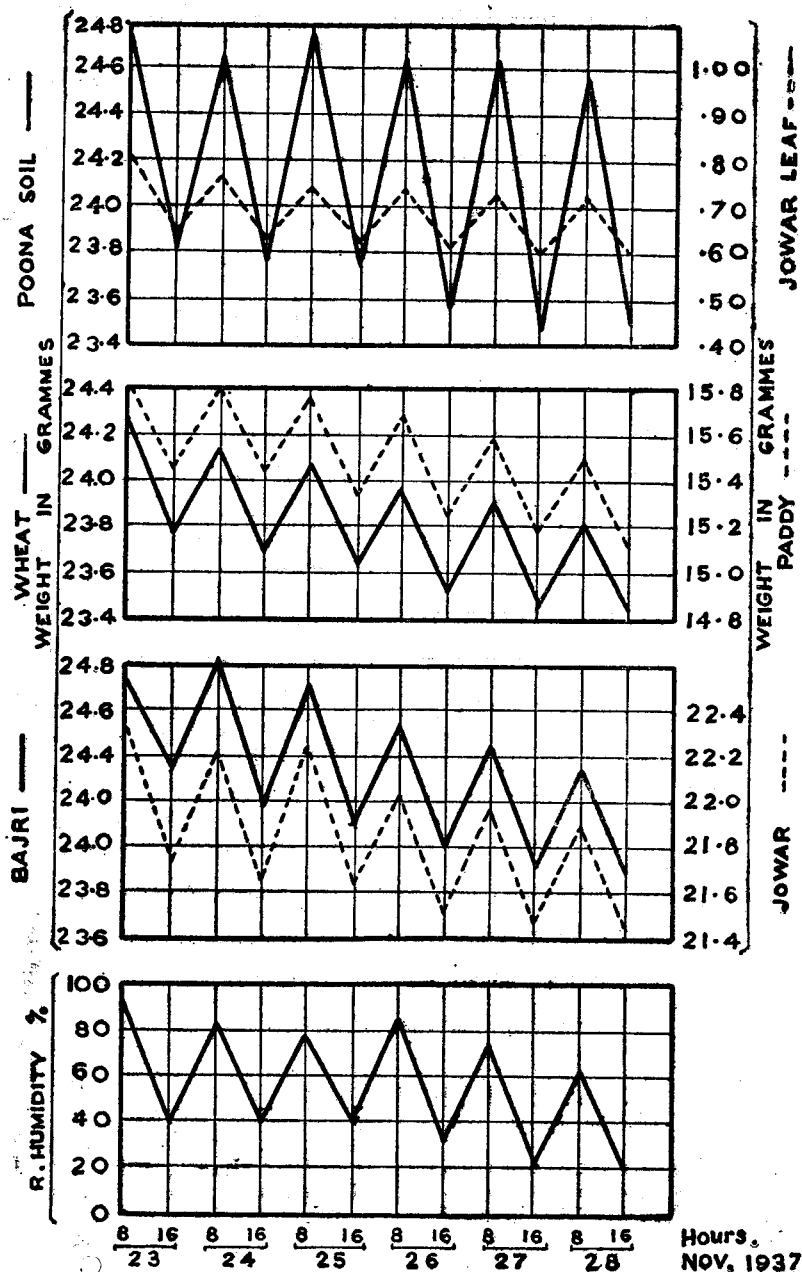


FIG. 1. Weights of samples of Poona soil, *jowar* leaf, wheat, paddy, *bajri* and *jowar* leaf exposed to the open in sun, and values of relative humidity at 0800 hrs. and 1600 hrs. daily from 23rd to 28th November 1937.

(b) The above experiment was repeated in January 1938 but this time the specimens were exposed inside a Stevenson screen at ground level.

Table II gives the weights in grams of the materials at 8 A.M. and 4 P.M. from the 17th to the 22nd January 1938.

At the bottom of Table II are given the mean weights of the samples at 8 A.M. and 4 P.M. as well as the differences between these mean 8 A.M. and 4 P.M. weights expressed as percentages of the mean weights for the day. The same results are shown graphically in Fig. 2.

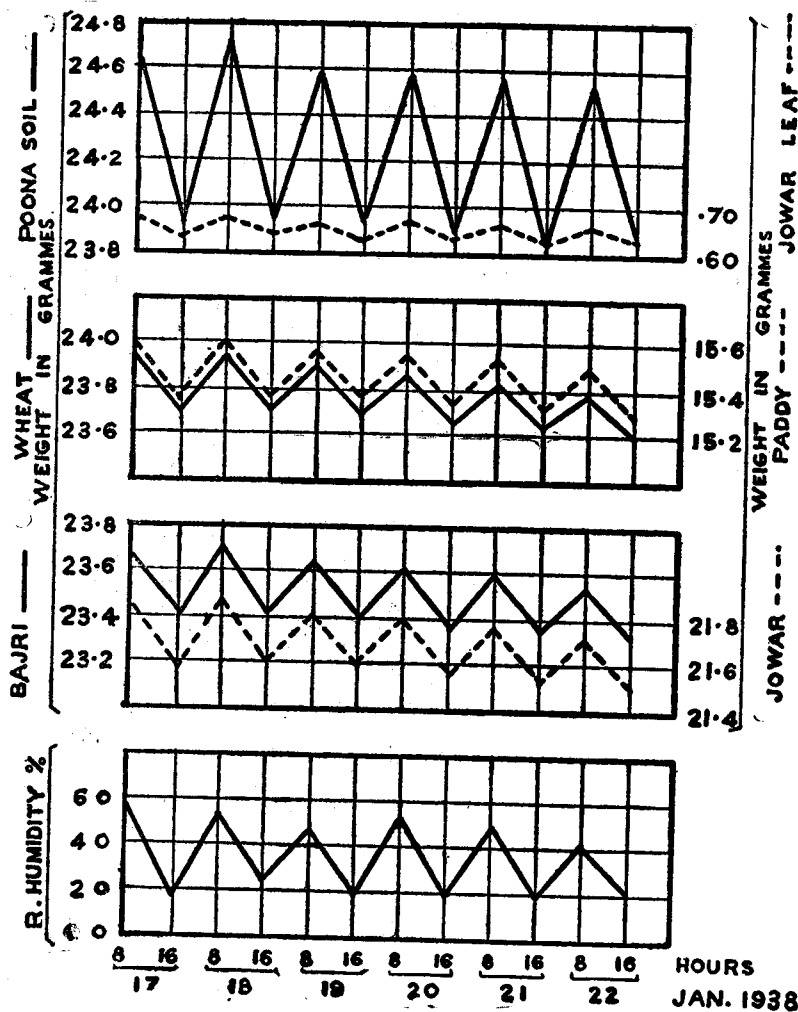


FIG. 2. Weights of samples of Poona soil, *jowar* leaf, wheat paddy, *bajri* and *jowar* exposed inside a Stevenson screen at ground level, and values of relative humidity at 0800 hrs. and 1600 hrs. daily from 17th to the 22nd January 1938,

TABLE I
Open (maximum and minimum weights in grms.)

Date	Time	Weight in grams						Soil	Wheat (grain)	Paddy (grain)	Bajri (grain)	Jowar (grain)	Jowar (leaf)	Dry bulb (°C.)	Wet bulb (°C.)	Vapour pressure (mm. of Hg)	Humidity (per cent)
23rd November 1937	8 A.M.	24.7343	24.2625	15.8561	24.7349	22.3078	0.8050	10.8	10.0	8.8	91						
	4 P.M.	23.8135	23.7737	15.3525	24.3445	21.7319	0.6536	29.8	20.3	13.1	42						
24th November 1937	8 A.M.	24.6641	24.1430	15.7957	24.8228	22.1974	0.7686	9.8	8.5	7.7	84						
	4 P.M.	23.7535	23.6925	15.4309	24.2100	21.6536	0.6364	30.4	20.3	12.8	39						
25th November 1937	8 A.M.	24.7675	24.0859	15.7743	24.7088	22.2468	0.7440	11.8	9.8	8.1	78						
	4 P.M.	23.7307	23.6339	15.3425	24.0970	21.6311	0.6293	29.4	19.8	12.5	41						
26th November 1937	8 A.M.	24.6605	23.9699	15.6648	24.5328	22.0029	0.7263	10.5	9.2	8.1	85						
	4 P.M.	23.5531	23.5215	15.2550	24.0126	21.5196	6.6194	30.2	19.0	10.9	34						
27th November 1937	8 A.M.	24.6304	23.9115	15.5846	24.4401	21.9651	0.7178	10.2	8.0	6.9	74						
	4 P.M.	23.4561	23.4741	15.1915	23.9345	21.4787	0.6006	31.5	17.2	7.6	22						
28th November 1937	8 A.M.	24.5957	23.8266	15.5077	24.3495	21.8984	0.7150	11.5	8.0	6.3	62						
	4 P.M.	23.4323	23.4163	15.1067	23.8735	21.4534	0.5926	33.5	17.5	7.0	18						
Mean weight		24.6754	24.0332	15.6972	24.5983	22.1031	0.7461	..	..	7.6	79				
		23.6232	23.5853	15.2800	24.0787	21.5747	0.6219	..	..	10.7	33				
Difference between the mean values at 8 A.M. and 4 P.M. expressed as percentages of the mean of the day		4.36	1.88	2.69	2.14	2.42	18.16	..	..	33.88	82.14				

TABLE II
Inside Stevenson screen at ground level (maximum and minimum weights in grms.)

Date	Time	Weight in grams								Wet bulb (°C.)	Dry bulb (°C.)	Vapour pressure (mm. of Hg.)	Humidity (per cent)
		Soil	Wheat (grain)	Paddy (grain)	Bejri (grain)	Jowar (grain)	Jowar (leaf)						
17th January 1938	8 A.M.	24.6746	23.9379	15.6000	23.6635	21.8378	0.6688	20.5	15.2	10.3	57		
	4 P.M.	23.9209	23.6999	15.3583	23.3947	21.5838	0.6333	32.5	17.2	7.1	19		
18th January 1938	8 A.M.	24.7209	23.9635	15.6143	23.7055	21.8842	0.6736	19.5	13.8	9.0	53		
	4 P.M.	23.9477	23.7099	15.3713	23.4211	21.6086	0.6352	31.5	17.8	8.4	24		
19th January 1938	8 A.M.	24.5957	23.9055	15.5675	23.6859	21.8194	0.6612	20.0	13.2	8.0	46		
	4 P.M.	23.9449	23.7031	15.3659	23.4047	21.5950	0.6336	32.0	16.5	6.3	18		
20th January 1938	8 A.M.	24.5813	23.8621	15.5479	23.6155	21.7998	0.6660	19.8	14.0	9.1	53		
	4 P.M.	23.8997	23.6591	15.3351	23.3665	21.5602	0.6340	31.5	16.5	6.6	19		
21st January 1938	8 A.M.	24.5597	23.8287	15.5279	23.5959	21.7734	0.6644	19.2	13.0	8.1	49		
	4 P.M.	23.8701	23.6391	15.3187	23.3527	21.5410	0.6304	32.5	16.8	6.5	18		
22nd January 1938	8 A.M.	24.5401	23.7843	15.4987	23.5379	21.7230	0.6644	20.5	13.0	7.5	41		
	4 P.M.	23.8549	23.6103	15.2853	23.3324	21.5106	0.6288	31.8	17.2	7.4	21		
Mean weight	8 A.M.	24.6121	23.8787	15.5594	23.6257	21.8063	0.6666	..	..	8.67	50
	4 P.M.	23.9063	23.6702	15.3394	23.3787	21.5665	0.6326	..	..	7.04	20
Difference between the mean values at 8 A.M. and 4 P.M. expressed as percentages of the mean of the day		2.91	0.88	1.42	1.05	1.11	5.23	..	..	..	..

B. Diurnal variation in the weights of specimens (due to exchange of moisture with the air layers near the ground)

(i) Specimens were kept in the open exposed to sun's rays and weighed every two hours from the morning of one day to the morning of the next day on two occasions, viz., 17th to 18th and 27th to 28th November 1937. Dry bulb and wet bulb temperatures of the air just above the specimens were also recorded by means of an Assmann Psychrometer.

Tables III and IV give the weights of the materials expressed as percentages of the mean weight as well as the dry bulb and wet bulb readings and the calculated vapour pressure and relative humidity values at two-hourly intervals.

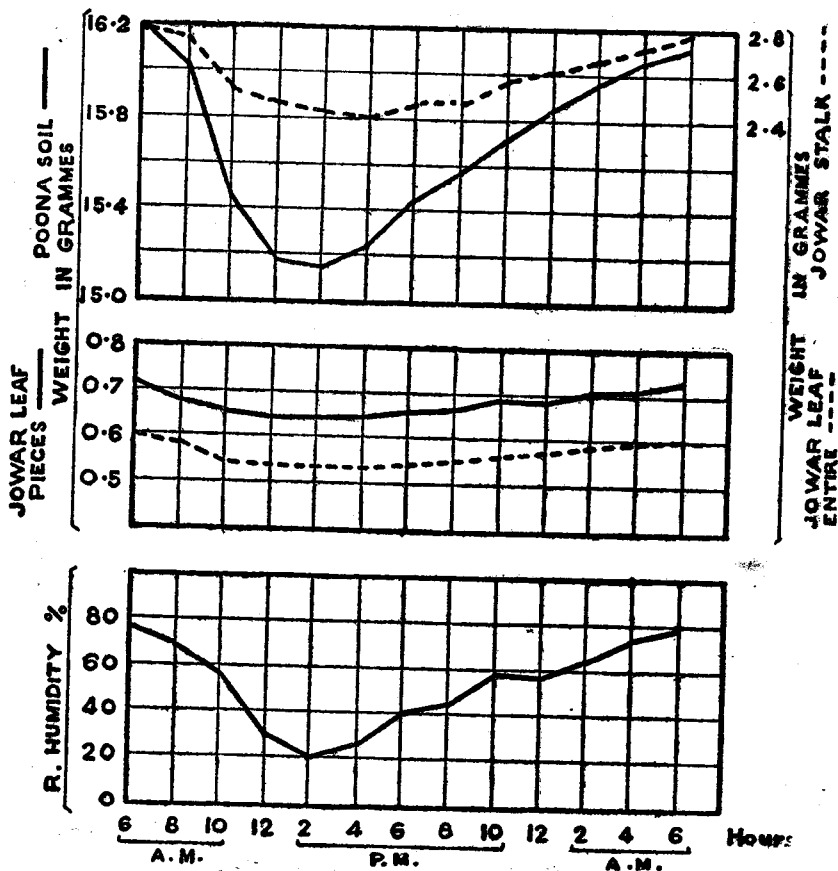


FIG. 3. Hourly variation of the weights of samples of Poona soil, *jowar* stalk, *jowar* leaves cut to pieces and *jowar* leaf entire, exposed to open in sun, and the relative humidity from 0600 hrs. on 17th November to 0600 hrs. on 18th November 1937.

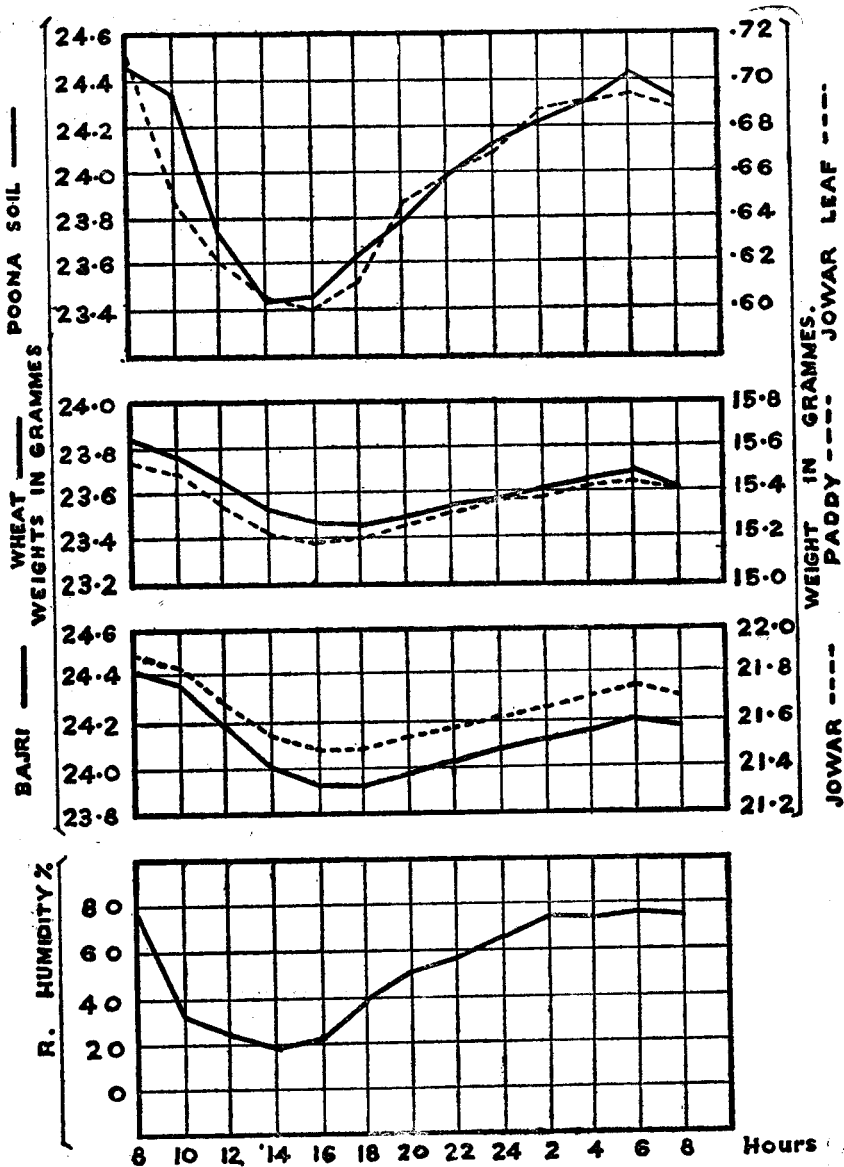


FIG. 4. Hourly variation of the weights of samples of Poona soil, *jowar* leaf, wheat, paddy, *bajri* and *jowar* exposed to open in sun and of the relative humidity from 0800 hrs. on 27th November to 0800 hrs. on 28th November 1937.

TABLE III

Exposed to open in sun (two-hourly observation ; actual weights expressed as percentages of mean weight)

Date	Time (hrs.)	Soil	Jowar stalk	Jowar leaf cut into pieces	Jowar leaf, entire	Dry bulb (°C.)	Wet bulb (°C.)	Vapour pressure (mm. of Hg.)	Relative humidity (per cent)
17th November 1937.	0800	103.3	107.6	105.9	109.5	9.8	7.8	6.9	76
Do.	0800	102.1	105.6	100.5	102.8	13.0	10.0	7.7	69
Do.	1000	98.5	97.6	96.3	95.8	21.8	18.1	10.9	56
Do.	1200	96.7	95.6	94.9	94.4	31.4	19.1	10.4	30
Do.	1400	96.5	93.9	94.9	94.1	36.0	19.8	9.2	21
Do.	1600	97.1	93.1	94.9	94.1	30.8	17.8	8.8	26
Do.	1800	98.4	95.3	96.6	95.5	24.0	15.5	9.0	40
Do.	2000	99.2	95.6	97.7	96.9	18.8	12.2	7.4	45
Do.	2200	100.2	99.5	101.1	99.3	14.2	10.0	7.1	59
Do.	2400	101.2	101.3	101.5	101.3	14.0	9.8	7.0	58
18th November 1937.	0200	101.6	103.0	103.6	103.0	12.5	9.2	7.1	65
Do.	0400	102.4	104.8	105.1	104.7	10.8	8.5	7.2	74
Do.	0600	102.8	107.1	106.9	108.7	9.9	8.0	7.2	79
100 per cent =		15.6926 grms.	2.5861 grms.	0.6803 grms.	0.5739 grms.				
Range of variation (per cent)		6.8	14.5	12.0	15.4				

TABLE IV

Exposed to open in sun (two-hourly observations ; actual weights expressed as percentages of the mean weight)

Date	Time (hours)	Soil	Wheat (grain)	Paddy (grain)	Bajri (grain)	Jowar (grain)	Jowar (leaf)	Dry bulb (°C.)	Wet bulb (°C.)	Vapour pressure (mm. of Hg.)	Humidity (per cent)
27th November 1937.	0800	101.8	101.0	101.3	101.2	101.2	108.5	15.5	13.0	10.0	76
Do.	1000	101.5	100.7	100.9	101.0	100.9	98.7	28.0	17.2	9.3	33
Do.	1200	98.5	100.2	100.0	100.3	100.2	94.5	31.5	18.0	8.7	25
Do.	1400	97.6	99.7	99.2	99.6	99.5	92.4	34.2	18.2	7.7	19
Do.	1600	97.7	99.4	98.9	99.2	99.2	91.5	31.5	17.2	7.6	22
Do.	1800	98.4	99.4	99.0	99.2	99.2	93.2	22.5	14.2	8.0	39
Do.	2000	99.1	99.5	99.4	99.4	99.5	98.5	16.7	11.2	7.2	51
Do.	2200	99.9	99.7	99.7	99.6	99.6	100.3	14.0	9.8	7.0	53
Do.	2400	100.4	99.9	100.0	99.8	99.8	102.1	12.2	9.0	7.0	66
28th November 1937.	0200	100.8	100.0	100.2	100.0	100.0	104.6	10.5	8.2	7.0	74
Do.	0400	101.3	100.2	100.4	100.1	100.2	105.1	9.8	7.6	6.7	74
Do.	0600	101.7	100.3	100.6	100.3	100.5	105.7	9.0	7.0	6.5	76
Do.	0800	101.3	100.0	100.5	100.3	100.2	104.8	14.5	12.0	9.3	75
100 per cent =		24.6730 grms.	23.6109 grms.	15.3831 grms.	24.1116 grms.	21.6496 grms.	0.6563 grms.				
Range of variation (per cent)		4.2	1.6	2.4	2.0	2.0	17.0				

(ii) The above experiment was repeated changing the condition of exposure. The specimens were exposed within a Stevenson screen at ground level. Table V gives the two-hourly weights expressed as percentages of the mean weight for the day and the dry bulb, wet bulb, vapour pressure and humidity values.

TABLE V

Inside Stevenson screen at ground level (two-hourly observations, actual weights expressed as percentages of the mean weight)

Date	Time (hours)	Soil	Wheat (grain)	Paddy (grain)	Bajri (rain)	Jowar (grain)	Jowar (leaf)	Dry bulb (°C.)	Wet bulb (°C.)	Vapour pressure (mm. of Hg)	Humidity (per cent)
11th January 1938.	0800	100.8	100.2	100.4	100.3	100.3	100.2	14.5	9.2	6.1	49
Do.	1000	100.8	100.3	100.3	100.3	100.3	98.2	23.5	13.8	7.0	32
Do.	1200	100.0	100.2	100.1	100.2	100.1	98.1	27.8	15.2	6.7	24
Do.	1400	99.2	99.9	99.7	99.9	99.9	98.1	32.5	17.2	7.1	19
Do.	1600	98.8	99.8	99.5	99.7	99.6	97.8	30.5	17.0	7.8	24
Do.	1800	98.6	99.6	99.3	99.5	99.4	97.7	23.2	17.2	9.2	32
Do.	2000	99.1	99.6	99.5	99.6	99.5	98.7	24.5	15.8	9.1	40
Do.	2200	99.6	99.7	99.6	99.7	99.6	99.8	20.5	13.8	8.5	47
Do.	2400	99.9	99.9	99.9	99.8	99.8	100.4	17.5	12.2	8.0	53
12th January 1938.	0200	100.2	100.	100.2	100.1	100.0	101.3	14.8	10.5	7.4	58
Do.	0400	100.5	100.2	100.4	100.2	100.2	102.9	12.2	9.2	7.2	68
Do.	0600	101.2	100.3	100.6	100.4	100.4	103.4	12.0	10.0	8.2	78
Do.	0800	101.2	100.3	100.6	100.4	100.7	103.5	14.2	9.8	6.9	57
100 per cent—		24.2642 grms.	23.7510 grms.	15.4192 grms.	23.4734 grms.	21.6658 grms.	0.6559 grms.				
Range of variation (per cent)		2.6	0.7	1.3	0.9	1.3	5.8				

(iii) In this experiment the materials were exposed to open but shaded from the sun.

Table VI gives the two-hourly weights expressed as percentages of the mean weight of the day as well as the dry bulb and wet bulb temperatures and the calculated vapour pressure and relative humidity values.

TABLE VI

Open (in shade) (two-hourly observations ; actual weights expressed as percentages of the mean weight)

Date	Time (hours)	Soil	Wheat (grain)	Paddy (grain)	Bajri (grain)	Jowar (grain)	Jowar (leaf)	Dry bulb (°C.)	Wet bulb (°C.)	Vapour pressure (mm. of Hg)	Humidity (per cent)
4th March 1938	0800	100.3	100.5	100.0	100.2	100.0	103.0	27.1	16.4	8.6	32
Do.	1000	99.1	99.9	99.7	99.7	99.8	101.7	31.7	17.4	7.8	22
Do.	1200	98.0	99.5	99.6	99.3	99.6	98.3	39.5	17.1	6.4	16
Do.	1400	98.0	99.5	99.5	99.2	99.4	95.4	38.5	18.0	5.2	10
Do.	1600	97.7	99.4	99.4	99.0	99.3	95.1	38.0	18.0	5.5	11
Do.	1800	98.3	99.4	99.5	99.3	99.5	96.5	33.0	20.2	11.4	30
Do.	2000	99.6	99.7	99.7	99.6	99.6	96.7	30.3	20.0	12.4	38
Do.	2200	100.6	99.7	99.9	99.8	99.8	97.0	28.0	18.5	11.2	40
Do.	2400	101.1	100.1	100.4	100.2	100.1	99.4	24.5	16.3	9.8	43
5th March 1938	0200	101.5	100.3	100.5	100.6	100.5	101.5	21.7	14.5	8.8	45
Do.	0400	102.0	100.6	100.7	101.0	100.8	104.0	19.5	13.3	8.3	49
Do.	0600	102.4	100.8	100.8	101.2	101.1	106.5	17.0	11.3	7.2	50
Do.	0800	101.3	100.5	100.2	100.8	100.4	104.5	23.4	17.3	11.8	55
100 per cent =		24.2104 grms.	23.2003 grms.	25.0679 grms.	22.8563 grms.	21.0889 grms.	0.2110 grms.				
Range of variation (per cent)		4.7	1.4	1.4	2.2	1.8	11.4				

(iv) In this experiment two sets were exposed simultaneously, one in the open with the sun's rays falling on the specimens while the other was exposed in the open but shaded from the sun. The specimens were weighed at two-hourly intervals and the readings of the dry bulb and wet bulb temperatures recorded at the same time.

Tables VII and VIII give the diurnal variation in the weights expressed as percentages of the mean weights for the whole day as well as the dry bulb, wet bulb, vapour pressure and relative humidity values.

TABLE VII

Exposed to the open in sun (two-hourly observations ; actual weights expressed as percentages of the mean weight)

Date	Time (hrs.)	Soil	Wheat (grain)	Paddy (grain)	Bajri (grain)	Jowar (grain)	Jowar (leaf)	Dry bulb (°C.)	Wet bulb (°C.)	Vapour pressure (mm. of Hg)	Humidity (per cent)
2nd May 1938	0800	105.9	102.5	103.2	104.2	102.7	124.1	36.5	19.0	7.7	17
Do.	1000	103.4	101.5	101.5	101.2	100.7	100.4	38.5	19.5	7.5	15
Do.	1200	97.0	99.7	99.3	99.8	99.8	75.7	43.5	20.5	6.6	10
Do.	1400	94.4	99.2	98.6	98.8	99.2	73.5	43.0	20.0	6.0	9
Do.	1600	94.8	98.8	98.2	98.0	98.7	71.6	42.0	21.2	8.5	14
Do.	1800	96.1	98.7	98.3	97.9	98.6	79.6	35.5	19.5	9.0	21
Do.	2000	97.8	99.0	99.0	98.5	98.9	91.3	31.5	21.5	14.2	41
Do.	2200	99.0	99.3	99.4	99.0	99.2	98.4	28.0	23.0	18.6	65
Do.	2400	100.7	99.5	99.7	99.6	99.5	104.4	25.2	24.0	21.8	91
3rd May 1938	0200	101.7	100.0	100.3	100.2	100.3	114.8	23.0	21.0	20.0	95
Do.	0400	102.5	100.4	100.6	100.7	100.7	120.3	21.5	19.5	18.4	96
Do.	0600	103.3	100.7	100.9	101.1	101.0	123.3	20.5	18.5	15.0	88
Do.	0800	103.2	100.7	100.9	101.0	100.9	123.0	34.5	25.0	19.0	46
100 per cent =		23.0254 grms.	26.5556 grms.	25.6193 grms.	20.5482 grms.	19.3589 grms.	1.3618 grms.				
Range of variation (per cent)		11.5	3.8	5.0	6.3	4.1	52.5				

TABLE VIII

Exposed to the open but always in shade (two-hourly observations ; actual weights expressed as percentages of the mean weight)

Date	Time (hrs.)	Soil	Wheat (grain)	Paddy (grain)	Bajri (grain)	Jowar (grain)	Jowar (leaf)	Dry bulb (°C.)	Wet bulb (°C.)	Vapour pressure (mm. of Hg)	Humidity (per cent)
2nd May 1938	0800	101.9	101.0	101.3	101.4	101.4	106.0	34.5	18.5	8.0	19
Do.	1000	100.2	100.3	100.2	100.5	100.6	99.4	37.5	18.2	6.0	12
Do.	1200	98.3	99.0	99.1	99.6	99.8	98.1	40.8	18.0	4.1	7
Do.	1400	98.0	99.4	98.8	99.2	99.5	93.6	41.0	19.8	6.7	11
Do.	1600	98.2	99.2	98.8	99.1	99.1	98.8	39.0	21.5	10.2	19
Do.	1800	98.8	99.1	99.0	99.0	99.0	99.0	36.5	20.6	10.2	22
Do.	2000	99.2	99.2	99.3	99.3	99.3	99.5	30.0	18.5	10.2	32
Do.	2200	99.6	99.5	99.6	99.6	99.6	99.9	26.5	22.7	18.8	72
Do.	2400	100.0	99.7	100.1	99.9	99.8	100.5	26.0	24.0	21.9	92
3rd May 1938	0200	100.6	100.2	100.5	100.2	100.2	101.0	22.5	22.0	19.6	96
Do.	0400	101.3	100.5	100.9	100.6	100.4	101.3	21.5	21.0	18.4	96
Do.	0600	102.0	101.0	101.3	100.9	100.8	101.8	20.5	18.5	15.0	83
Do.	0800	101.8	100.9	101.2	100.8	100.5	101.5	32.0	28.3	23.2	65
100 per cent =		22.8402 grms.	20.5787 grms.	24.3880 grms.	24.0255 grms.	22.7844 grms.	1.1888 grms.				
Range of variation (per cent)		4.0	1.9	2.5	2.4	2.4	12.4				

IV. DISCUSSION

A. Explanation of the results

From the foregoing account it emerges that plant materials exchange moisture with the air layers surrounding them just as the soils do. The curves of diurnal exchange of moisture by plant materials are somewhat similar to that of the soil; both the soil as well as the plant materials lose moisture from morning till afternoon, but regain during the afternoon and night almost all the moisture lost during the day. There is also a striking similarity in the form of the curves of soil and plant materials to that of relative humidity. In other words, as the relative humidity of the air decreases, soil and plant materials tend to give up moisture to the air layers, but when the relative humidity of the air increases, they desiccate the atmosphere by absorbing moisture from the air layers surrounding them.

B. Maximum and minimum moisture content

The epochs of maximum and minimum moisture contents vary slightly in the different cases. In soils the epoch of minimum moisture content coincides with the maximum temperature epoch while the maximum moisture content occurs at the same time as the minimum temperature epoch. In the case of plant materials, except when the materials are exposed inside a Stevenson screen, the maximum moisture content occurs about the same time as the minimum temperature epoch, *i.e.*, at about 6 A.M. The loss of weight from 6 A.M. to 8 A.M., however, is not so well marked as in the case of soil. While the soil starts losing moisture from 6 A.M., the loss of weight from 6 to 8 A.M. is generally not very striking in the case of plant materials. Inside a Stevenson screen the intensity of the phenomenon is less and there is a general lag; the plant materials attain their maximum weight only at 8 A.M., and not at 6 A.M. as in the other cases when exposed to the open.

The minimum moisture content of plant materials, unlike soils, does not occur exactly at the maximum temperature epoch. In this respect, the plant materials studied show difference even amongst themselves, some showing the minimum weight at about 2 P.M. as the soil does, while others go on losing weight till as late as 6 P.M. It is seen that, in general, plant materials attain their minimum moisture content a little later than the soil, materials like seed grains showing a greater lag than do specimens of dry *jowar* stalk or leaf. Thus, the lag, which is slightly noticeable at the maximum moisture epoch, becomes strikingly apparent (4 hours sometimes) during the minimum moisture epoch. The exchange of moisture between a soil in a finely divided state and the air is more rapid than in the case of the plant materials. In the case of plant materials the process is not so rapid because of the cell walls through which the water vapour has to pass in getting in or going out. The seed-coat of the grains is still less permeable to water vapour than the dry cells of *jowar* leaf or stalk and hence the lag in the epochs of maximum and minimum moisture content is more in the case of the grains than in the case of dry *jowar* leaves and stalks.

C. Diurnal variation in moisture content under different conditions

The difference between the maximum and minimum weights, or the amplitude of variation expressed on percentage basis, is shown in Table IX.

TABLE IX

The amplitude of variation in weight (or the maximum weight minus the minimum weight expressed as a percentage of the mean weight), on different days and under different conditions of exposure

Materials	17th November 1937, exposed to open, in sun	27th November 1937, exposed to open, in sun	11th January 1938, exposed inside S.S. at ground level	4th March 1938, exposed to open, shad- ed from sun	2nd May 1938, exposed to open, in sun	2nd May 1938, exposed to open, shaded from sun
	1	2	3	4	5	6
1. Black cotton soil.	6.8	4.2	2.6	4.7	11.5	4.0
2. Wheat grains	..	1.6	0.7	1.4	3.8	1.9
3. Paddy grains	..	2.4	1.3	1.4	5.0	2.5
4. <i>Bajri</i> grains	..	2.0	0.9	2.2	6.3	2.4
5. <i>Jowar</i> grains	..	2.0	1.3	1.8	4.1	2.4
6. <i>Jowar</i> leaf cut into pieces	12.0	17.0	5.8	11.4	52.5	12.4
7. <i>Jowar</i> leaf entire	15.4					
8. <i>Jowar</i> stalk cut into pieces	14.5					

Table IX brings out the following points :—

(1) The diurnal variation is greatest in dry plant materials like *jowar* leaf and stalk and least in the seed grains, while soil occupies an intermediate position in this respect.

(2) The diurnal variation is maximum when the samples are exposed to the sun, and minimum when they are exposed in a Stevenson screen ; when exposed in the open but shaded from sun, the values are intermediate between those in the above two cases.

(3) The effect of season can be studied by comparing column 2 with column 5 as well as column 4 with column 6 where the same materials were exposed to identical conditions in different parts of the year. It becomes clear from the above comparison that the exchange of moisture between soil and plant materials and the air layers surrounding them is greater in the hotter than in the colder parts of the year.

(4) The effect of insolation is clearly brought out by a comparison of columns 5 and 6. The conditions of exposure were similar in all respects except

that in one case the direct insolation was out off. It is seen that just by cutting off the insolation the amplitude of the variation in weights is reduced by about 50 per cent.

Significance of the above results in agricultural practice

The fact that dry plant materials lose moisture during the day and regain during the night may have a bearing on agricultural marketing. From what has been said it is evident that a difference between the maximum and minimum weights (for materials like dry *jowar* stalk and leaf) equivalent to about 10-15 per cent of the mean weight for the day is not unusual when the material is fully spread out. In actual practice grain and fodder are handled in bulk and it is necessary to find out how the diurnal variation of moisture content would alter under those conditions. Further work on these lines will be attempted during the next clear season.

V. SUMMARY AND CONCLUSIONS

(1) It has been shown that dry plant materials exchange moisture with the air layers surrounding them just as the soils do.

(2) The amount of the moisture exchanged is greater than in the soil in the case of materials like dry *jowar* stalk and leaf, while in the case of grains like wheat, paddy, *bajri* and *jowar* the moisture exchanged is less than that by the soil.

(3) The difference between the maximum and minimum moisture content is greatest in materials exposed to open in sun, smaller when exposed to open shaded from sun and least when the specimens are exposed within a Stevenson screen at ground level.

(4) The amplitude of the variation in weight is greater in summer than in winter.

(5) The agricultural bearing of these results has been indicated.

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