

Combining Eqs. (1) and (3), we get the remarkable relation

$$4 \frac{F_K}{F_\pi} M_K^2 = 4 \frac{F_K}{F_\pi} - 1 M_\eta^2 + M_\pi^2 \quad (4)$$

which is the modified Gell-Mann-Okubo mass formula obtained from the (8,8) model of the broken  $SU(3) \times SU(3)$  symmetry.

We note here that in the limit of an exact  $SU(3)$  symmetry (i.e.  $F_K \approx F_\pi$ ), Eq. (4) reduces to the original Gell-Mann-Okubo mass formula<sup>6</sup> for the pseudoscalar mesons:

$$4 M_K^2 = 3 M_\eta^2 + M_\pi^2 \quad (5)$$

If we use the average experimental masses of  $\pi$ ,  $K$  and  $\eta$  in Eq. (5), it is satisfied to within 6.3%. On the other hand, if we use the accepted value  $F_K/F_\pi = 1.25$ , along with the experimental masses, as input in our modified relation (4), we find that the agreement is of the order of 0.4%. Thus our modified formula is much better than the original mass formula

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## EVALUATION OF NITRATE DISPLACEMENT AND WETTING FRONT DEPTH FOLLOWING INFILTRATION IN COARSE-TEXTURED SOIL

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In soil, fertilizer nitrogen is mostly converted into nitrate form which moves through the soil with irrigation water. The nitrate is either available to the crops or is leached down beyond the root zone. Prediction of nitrate movement under varying

amounts of water supply is thus, important for optimizing nitrogen management in soil. Such a study usually requires solving the second order partial differential equation for water flow, measurement of Darcian flow velocity, constant monitoring of influx rate and lengthy mathematical computations<sup>1-4</sup>. Recently Rose *et al*<sup>5</sup> advocated simplified mathematical treatment to predict nitrate movement in soil under field conditions. The present study attempts to determine if nitrate displacement depth in coarse-textured soil could be computed by simple mathematical relationships.

Nitrate movement was studied in laboratory experiments, using alluvial sandy loam soil (a typical Ustochrept having clay 18.6% silt 12.5% and sand 68.9%) during downward as well as horizontal infiltration of water at two levels of bulk densities (1.5 and 1.6 g cm<sup>-3</sup>), each at two initial soil water contents (0.02 and 0.08 cm<sup>3</sup> cm<sup>-3</sup>). Three different quantities of water (2.5, 5.1 and 8.6 cm) were allowed to infiltrate through one end of the soil column where chemical grade potassium nitrate (at the rate of 562.5  $\mu$ g of N per gram of soil mixed in 2 cm layer) was added. After the entry of desired quantity of water, nitrate as well as water contents were determined at different soil depths and the maximum nitrate concentration displacement ( $X_m$ ) and wetting front depths ( $X_f$ ) were found out. The details of the experimental procedures were similar to those reported earlier<sup>3</sup>.

During the study, it was observed that the nitrate moved with the water flowing through the profile and the depth of the fertilizer displacement increased proportionately with the quantity of influx (table 1). The depth of maximum nitrate concentration ( $X_m$ ) was not affected by the initial soil wetness for any particular amount of infiltration and the wetting front ( $X_f$ ) coincided with  $X_m$  in initially dry soil. However, in initially moist soil  $X_m$  lagged behind  $X_f$ . The lagging effect became more pronounced with higher quantum of infiltration as the invading solution displaced more of the antecedent water from a larger soil volume which increased as water penetrated deeper in the profile. These observations were similar to the earlier findings in the case of nitrate<sup>3,6</sup> and chloride<sup>7</sup> both showing similar behaviour. It was also observed that irrespective of the quantity of water influx the soil water content distribution in the wetted profile was fairly uniform and the average profile water content  $\theta_r$  following infiltration was 0.3329 and 0.3216 cm<sup>3</sup> cm<sup>-3</sup> for 1.5 and 1.6 g cm<sup>-3</sup> bulk densities. These  $\theta_r$  values were used in the following three equations to compute  $X_f$ ,  $X_m$  and the lag factor  $Y$ .

$$X_f = Q_r (\theta_r - \theta_i) \quad (1)$$

$$X_m = Q_r \theta_r \quad (2)$$

TABLE 1

Experimental (E) and predicted (P) depths of wet front ( $X_f$ ) and maximum nitrate concentration ( $X_m$ ) and the lag (Y) between the two for different amount of water influx (Q) through an alluvial sandy loam soil profile having two different initial moisture contents ( $\theta_i$ ) and bulk densities (B.D.)

Q (cm)	Parameter evaluated	$\theta_i$ (cm <sup>3</sup> cm <sup>-3</sup> )			
		0.02		0.08	
		E	P	E	P
2.5	$X_f$	8	7.99	11	7.89
	$X_m$	4-6	7.51	6-8	7.51
	Y		0.48		2.38
5.1	$X_f$	16	16.30	18	20.17
	$X_m$	14-15	15.32	14-16	15.32
	Y		0.98		4.85
8.6	$X_f$	26	27.48	*	34.01
	$X_m$	22-24	25.83	*	25.83
	Y		1.65		8.17
(B.D. 1.6 g cm <sup>-3</sup> )					
2.5	$X_f$	8	8.29	11	10.35
	$X_m$	6-8	7.77	6-8	7.77
	Y		0.52		2.57
5.1	$X_f$	16	16.01	22	21.11
	$X_m$	14-16	15.86	14-16	15-86
	Y		1.05		5.25
8.6	$X_f$	27	28.51	*	35.60
	$X_m$	24-26	26.74	*	26.74
	Y		1.77	*	8.85

\* Experimental values could not be determined as water accumulated within 30 cm long soil column used for the experiment, which otherwise would have penetrated beyond this depth.

$$y = \frac{\theta_i}{\theta_r(\theta_r - \theta_i)} Q \quad (3)$$

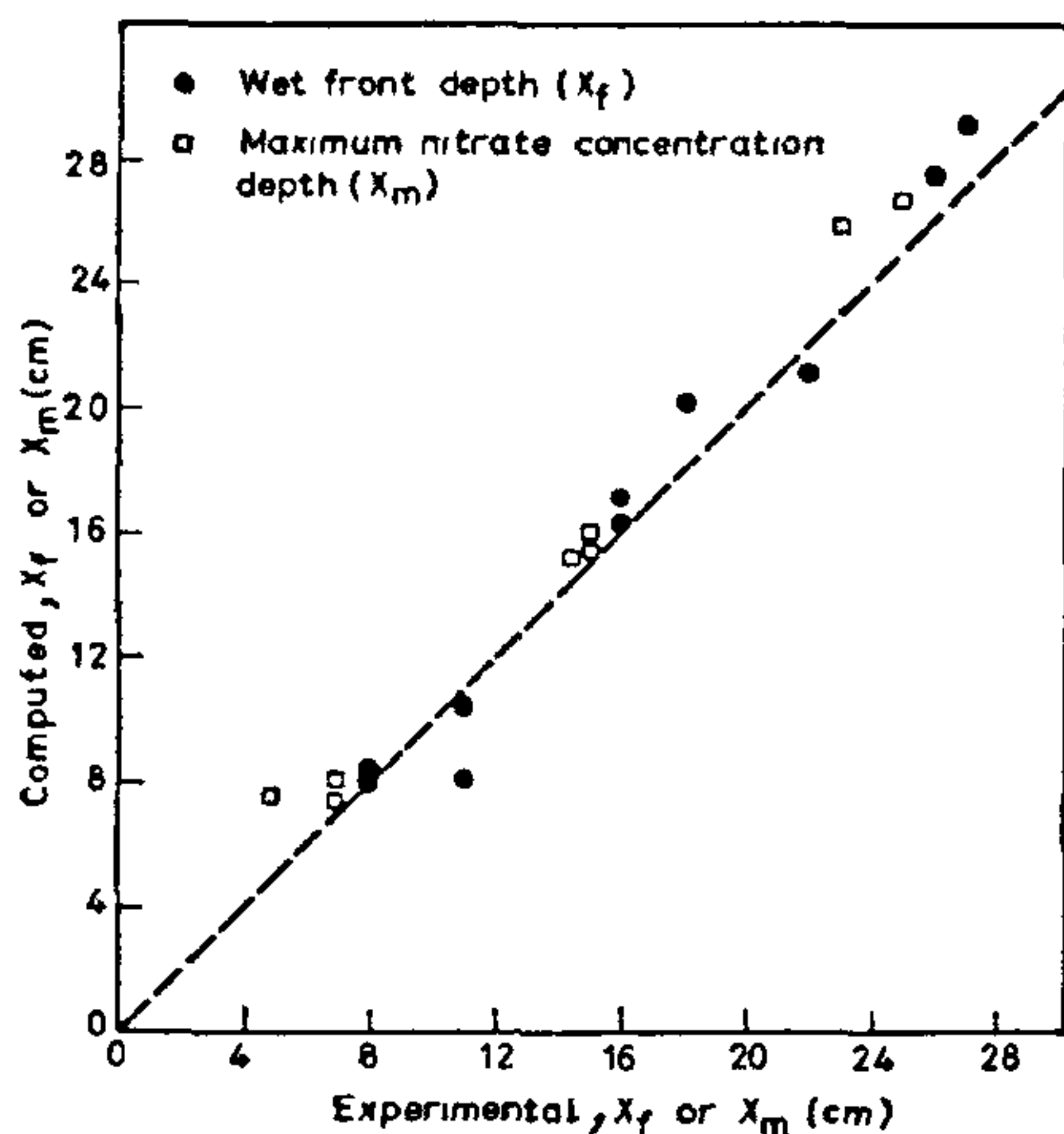
where  $Q$  is the cumulative water flux,  $\theta_i$  and  $\theta_r$  are the initial and average soil water contents of the profile following infiltration. The  $Y$  value was taken as the difference between  $X_f$  and  $X_m$  since this lag, as stated earlier, was created due to the presence of antecedent water displaced by the incoming water and accumulated in the zone beyond the penetration depth of the displacing solution.

For brevity the results of the experimentally observed values of  $X_f$  and  $X_m$  and their computed values are graphically presented in figure 1. The data showed good agreement between experimentally observed and computed values of  $X_f$  and  $X_m$  for the different quantities of water infiltrated. The dashed line in figure 1 showed the hypothetical cent percent correspondence between the expected and computed values. The marked prints in the scatter diagram showing computed  $X_f$  and  $X_m$  values were very close to the dashed line and  $\chi^2$  test also indicated that the

goodness of fit between the experimental and computed values were highly significant.

The results indicate that once the average soil water content  $\theta_r$  is evaluated for a given soil at a particular bulk density, it would be possible to evaluate  $X_f$ ,  $X_m$  and  $Y$  from the above simplified equations provided the amount of water influx could be monitored. The equations will hold good for unsaturated moisture movement where most of the water is assumed to move by piston flow.

There is apprehension that in soils volatilization or denitrification losses of nitrogen may occur, as is prevalent in waterlogged soil, particularly over longer duration of time. However, in well-drained, arable and coarse-textured soils such losses are negligible, more so over short period following infiltration as observed in the present study. Hence it is believed that equations (1) and (2) would provide fairly reliable estimates of wetting front and nitrate displacement depths following infiltration of irrigation water in such soils. It is quite evident that the magnitude of



**Figure 1.** Experimental versus computed wet front depth,  $X_f$ , and maximum nitrate concentration depth,  $X_m$ , ( $X^2$  at 99% probability for observed value of  $X_f$  is 1.452 and for  $X_m$  is 2.088. Table value = 2.558 for  $n = 10$ )

peak nitrate concentration would be reduced depending upon the extent of denitrification or other losses.

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## TRITERPENOIDS OF *CORIANDRUM SATIVUM* SEEDS

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FROM the seeds of *Coriandrum sativum* Linn. an Indian medicinal plant, a number of substances have been isolated including volatile oils<sup>1</sup>. It was found that the locally available seeds are of two varieties, the Indore variety and the Bombay variety. From the first we have isolated an aliphatic alcohol, m.p. 80–81°, and an aliphatic ketone, m.p. 68–70°, in addition to  $\beta$ -sistosterol and  $\beta$ -sistosterol-D-glucoside, which was wrongly assumed to be a new triterpenoid designated as 'Coriandrinol' by previous authors<sup>2</sup>. The present paper deals with the structure of a new triterpenoid, coriandrinone-diol (I), isolated from the cold alcoholic extract of the Bombay variety of dried seeds after saponification with alcoholic alkali and column chromatography on neutral alumina (benzene-ether 3:1) in 0.006% yield.

Compound I,  $C_{30}H_{50}O_3$  ( $M^+$  458),  $[\alpha]_D^{23} + 38.3^\circ$  ( $CHCl_3$ ) isolated as colourless crystalline needles (MeOH-ether), m.p. 285–90° showed UV:  $\lambda_{max}^{MeOH}$  270 nm (log  $\epsilon$  3.19) for a saturated carbonyl function. Its IR (KBr), revealed absorption bands at 3405 (br) and 3505  $cm^{-1}$ , characteristic of a bonded and a free hydroxyl group respectively, in addition to the band at 1695  $cm^{-1}$  for a six-membered ring ketone. However, the PMR spectrum of the substance was not available due to its insolubility in common organic solvents. The compound failed to give a 2,4-dinitrophenylhydrazone derivative indicating that the ketone group was probably highly hindered. It gave positive Liebermann-Burchard, Salkowski and Noller tests for a pentacyclic triterpenoid.

On acetylation it gave only a monoacetate  $C_{32}H_{52}O_4$  ( $M^+$  500), m.p. 299–300°. IR  $^{KBr}$  showed absorption bands at 3405, 1720 and 1699  $cm^{-1}$  characteristic of a hydroxyl, an acetyl carbonyl and a six-membered ring ketone. The formation of a monoacetate reveals that the triterpenoid is a keto-diol, in which one of the hydroxyl groups is either tertiary or is a highly hindered one.

The PMR ( $CDCl_3$ ) spectrum of the monoacetate showed signals for eight tertiary methyls at  $\delta$  0.71 (3H, s), 0.76 (3H, s), 0.80 (9H, s), 0.89 (6H, s) and 1.40 (3H, s) ppm in addition to the signal at  $\delta$  1.96 ppm (3H, s,  $CH_3-CO-O-$ ) indicating that all the methyls of the squalene precursor are intact. The signals at 2.67 (2H, t,  $J=13.5Hz$ ), 3.47 (1H, dd,  $J=12.3$  and 4.0 Hz) and