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LAMPIRAN

1. Titik Kesetimbangan Endemik dengan Maple 16

```
restart:
#c1:=(α+μ+λ);c2:=(1-p1)·λ;c3:=(α+μ+σ1+ψ1);c4:=(p1·λ);c5:=((1-q1)·δ1);c6:=(μ+d1+(τ·α)+w1+n1);c7:=(α+μ);c8:=(μ+λθ);c9:=(θ·(1-p2)
·λ);c10:=(μ+θ·σ2+ψ2);c11:=(τ·α);c12:=(θ·p2·λ);c13:=(θ·σ2);c14:=((1-q1)·δ1·θ);c15:=(μ+d2+w2+n2);c16:=(γ1+γ2+μ);

> per1:=k-c1·S1·I1;
per1 := -I1 S1 c1 + k (1)

> per2:=c2·S1·I1-c3·E1;
per2 := I1 S1 c2 - E1 c3 (2)

> per3:=c4·S1·I1+σ1·E1+c5·T-c6·I1;
per3 := I1 S1 c4 + E1 σ1 - I1 c6 + T c5 (3)

> per4:=n1·I1+γ1·T-c7·R1;
per4 := I1 n1 - R1 c7 + T γ1 (4)

> per5:=α·S1-c8·S2;
per5 := S1 α - S2 c8 (5)

> per6:=α·E1+c9·S2·I2-c10·E2;
per6 := I2 S2 c9 + E1 α - E2 c10 (6)

> per7:=c11·I1+c12·S2·I2+c13·E2+c14·T-c15·I2;
per7 := I2 S2 c12 + E2 c13 + I1 c11 - I2 c15 + T c14 (7)

> per8:=α·R1+n2·I2+γ2·T-μ·R2;
per8 := I2 n2 + R1 α - R2 μ + T γ2 (8)

> per9:=w1·I1+w2·I2+ψ1·E1+ψ2·E2-(c5+c14+c16)·T;
per9 := w1 I1 + w2 I2 + ψ1 E1 + ψ2 E2 - (c5 + c14 + c16) T (9)

>
> solve({per1,per2,per3,per4,per5,per6,per7,per8,per9},{S1,I1,R1,S2,E2,I2,R2,T});
E1 = -k c2 / c1 c3, E2 = (α k (-c9 α c12 c2 c5 ψ2 - c9 c10 c12 c14 c2 c1 - c9 c10 c12 c14 c3 c4 - c9 c10 c12 c16 c3 c4 - c9 c10 c12 c2 c5 ψ1 - c9 c10 c12 c2 c5 c1
-c9 c10 c12 c3 c4 c5 + RootOf((c10 c11 c3 c5 c8 w2 - c10 c14 c15 c3 c6 c8 + c10 c14 c3 c6 c8 w2 - c10 c15 c16 c3 c6 c8 - c10 c15 c3 c5 c6 c8 + c10 c15 c3 c5 c8 w1) _Z^2
- α^2 c12 c2 c5 ψ2 - α c10 c12 c14 c2 c1 - α c10 c12 c14 c3 c4 - α c10 c12 c16 c2 c1 - α c10 c12 c16 c3 c4 - α c10 c12 c2 c5 ψ1 - α c10 c12 c2 c5 c1 - α c10 c12 c3 c4 c5
- α c13 c14 c2 c9 c1 - α c13 c14 c3 c4 c9 - α c13 c16 c2 c9 c1 - α c13 c16 c3 c4 c9 - α c13 c2 c5 c9 ψ1 - α c13 c2 c5 c9 c1 - α c13 c3 c4 c5 c9 - α c14 c2 c9 ψ2 c1
- α c14 c3 c4 c9 ψ2 + (-c10 c14 c2 c8 c1 w2 - c10 c14 c3 c4 c8 w2 + c10 c14 c15 c2 c8 c1 + c10 c14 c15 c3 c4 c8 + c10 c15 c16 c2 c8 c1 + c10 c15 c16 c3 c4 c8
+ c10 c15 c2 c5 c8 w1 + c10 c15 c2 c5 c8 c1 + c10 c15 c3 c4 c5 c8 + c14 c12 c10 α c3 c6 + α c10 c12 c16 c3 c6 + α c10 c12 c3 c5 c6 - α c10 c12 c3 c5 w1 + α c11 c3 c5 c9 ψ2
+ α c13 c2 c5 c8 w2 + α c14 c3 c6 c9 ψ2 + α c15 c2 c5 c8 w2 + α c13 c14 c3 c6 c9 + α c13 c16 c3 c6 c9 + α c13 c3 c5 c6 c9 - α c13 c3 c5 c9 w1) _Z) c10 c12 c2 c5 c8 w2
+ RootOf((c10 c11 c3 c5 c8 w2 - c10 c14 c15 c3 c6 c8 + c10 c14 c3 c6 c8 w2 - c10 c15 c16 c3 c6 c8 - c10 c15 c3 c5 c6 c8 + c10 c15 c3 c5 c8 w1) _Z^2 - α^2 c12 c2 c5 ψ2
- α c10 c12 c14 c2 c1 - α c10 c12 c14 c3 c4 - α c10 c12 c16 c2 c1 - α c10 c12 c16 c3 c4 - α c10 c12 c2 c5 ψ1 - α c10 c12 c2 c5 c1 - α c10 c12 c3 c4 c5 - α c13 c14 c2 c9 c1
- α c13 c14 c3 c4 c9 - α c13 c16 c2 c9 c1 - α c13 c16 c3 c4 c9 - α c13 c2 c5 c9 ψ1 - α c13 c2 c5 c9 c1 - α c13 c3 c4 c5 c9 - α c14 c2 c9 ψ2 c1 - α c14 c3 c4 c9 ψ2 + (-
-c10 c14 c2 c8 c1 w2 - c10 c14 c3 c4 c8 w2 + c10 c14 c15 c2 c8 c1 + c10 c14 c15 c3 c4 c8 + c10 c15 c16 c2 c8 c1 + c10 c15 c16 c3 c4 c8 + c10 c15 c2 c5 c8 w1 + c10 c15 c2 c5 c8 c1
+ c10 c15 c3 c4 c5 c8 + c14 c12 c10 α c3 c6 + α c10 c12 c16 c3 c6 + α c10 c12 c3 c5 c6 - α c10 c12 c3 c5 w1 + α c11 c3 c5 c9 ψ2 + α c13 c2 c5 c8 w2 + α c14 c3 c6 c9 ψ2
+ α c15 c2 c5 c8 w2 + α c13 c14 c3 c6 c9 + α c13 c16 c3 c6 c9 + α c13 c3 c5 c6 c9 - α c13 c3 c5 c9 w1) _Z) c13 c2 c5 c8 c9 w2 + RootOf((c10 c11 c3 c5 c8 w2 - c10 c14 c15 c3 c6 c8
+ c10 c14 c3 c6 c8 w2 - c10 c15 c16 c3 c6 c8 - c10 c15 c3 c5 c6 c8 + c10 c15 c3 c5 c8 w1) _Z^2 - α^2 c12 c2 c5 ψ2 - α c10 c12 c14 c2 c1 - α c10 c12 c14 c3 c4 - α c10 c12 c16 c2 c1
- α c10 c12 c16 c3 c4 - α c10 c12 c2 c5 ψ1 - α c10 c12 c2 c5 c1 - α c10 c12 c3 c4 c5 - α c13 c14 c2 c9 c1 - α c13 c14 c3 c4 c9 - α c13 c16 c2 c9 c1 - α c13 c16 c3 c4 c9
- α c13 c2 c5 c9 ψ1 - α c13 c2 c5 c9 c1 - α c13 c3 c4 c5 c9 - α c14 c2 c9 ψ2 c1 - α c14 c3 c4 c9 ψ2 + (-c10 c14 c2 c8 c1 w2 - c10 c14 c3 c4 c8 w2 + c10 c14 c15 c2 c8 c1
+ c10 c14 c15 c3 c4 c8 + c10 c15 c16 c2 c8 c1 + c10 c15 c16 c3 c4 c8 + c14 c12 c10 α c3 c6 + α c10 c12 c16 c3 c6 + α c10 c12 c3 c5 c6 - α c10 c12 c3 c5 w1 + α c11 c3 c5 c9 ψ2
+ α c13 c2 c5 c8 w2 + α c14 c3 c6 c9 ψ2 + α c15 c2 c5 c8 w2 + α c13 c14 c3 c6 c9 + α c13 c16 c3 c6 c9 + α c13 c3 c5 c6 c9 - α c13 c3 c5 c9 w1) _Z) c13 c2 c5 c8 c9 w2 + RootOf((c10 c11 c3 c5 c8 w2 - c10 c14 c15 c3 c6 c8
+ c10 c14 c3 c6 c8 w2 - c10 c15 c16 c3 c6 c8 - c10 c15 c3 c5 c6 c8 + c10 c15 c3 c5 c8 w1) _Z^2 - α^2 c12 c2 c5 ψ2 - α c10 c12 c14 c2 c1 - α c10 c12 c14 c3 c4 - α c10 c12 c16 c2 c1
- α c10 c12 c16 c3 c4 - α c10 c12 c2 c5 ψ1 - α c10 c12 c2 c5 c1 - α c10 c12 c3 c4 c5 - α c13 c14 c2 c9 c1 - α c13 c14 c3 c4 c9 - α c13 c16 c2 c9 c1 - α c13 c16 c3 c4 c9
- α c13 c2 c5 c9 ψ1 - α c13 c2 c5 c9 c1 - α c13 c3 c4 c5 c9 - α c14 c2 c9 ψ2 c1 - α c14 c3 c4 c9 ψ2 + (-c10 c14 c2 c8 c1 w2 - c10 c14 c3 c4 c8 w2 + c10 c14 c15 c2 c8 c1
+ c10 c14 c15 c3 c4 c8 + c10 c15 c16 c2 c8 c1 + c10 c15 c16 c3 c4 c8 + c14 c12 c10 α c3 c6 + α c10 c12 c16 c3 c6 + α c10 c12 c3 c5 c6 - α c10 c12 c3 c5 w1 + α c11 c3 c5 c9 ψ2
+ α c13 c2 c5 c8 w2 + α c14 c3 c6 c9 ψ2 + α c15 c2 c5 c8 w2 + α c13 c14 c3 c6 c9 + α c13 c16 c3 c6 c9 + α c13 c3 c5 c6 c9 - α c13 c3 c5 c9 w1) _Z) c13 c14 c3 c6 c9 + α c13 c16 c3 c6 c9
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$$\begin{aligned}
& -\alpha c13c3c5c9w1) _Z) c11c3c5c8w2 + c7n2 \text{RootOf}((c10c11c3c5c8w2 - c10c14c15c3c6c8 + c10c14c3c6c8w2 - c10c15c16c3c6c8 - c10c15c3c5c8c8 \\
& + c10c15c3c5c8w1) _Z^2 - \alpha^2 c12c2c5\psi2 - \alpha c10c12c14c2\sigma1 - \alpha c10c12c14c3c4 - \alpha c10c12c16c2\sigma1 - \alpha c10c12c16c3c4 - \alpha c10c12c2c5\psi1 - \alpha c10c12c2c5\sigma1 \\
& - \alpha c10c12c3c4c5 - \alpha c13c14c2c9\sigma1 - \alpha c13c14c3c4c9 - \alpha c13c16c2c9\sigma1 - \alpha c13c16c3c4c9 - \alpha c13c2c5c9\psi1 - \alpha c13c2c5c9\sigma1 - \alpha c13c3c4c5c9 \\
& - \alpha c14c2c9\psi2\sigma1 - \alpha c14c3c4c9\psi2 + (-c10c14c2c8\sigma1w2 - c10c14c3c4c8w2 + c10c14c15c2c8\sigma1 + c10c14c15c3c4c8 + c10c15c16c2c8\sigma1 + c10c15c16c3c4c8 \\
& + c10c15c2c5c8\psi1 + c10c15c2c5c8\sigma1 + c10c15c3c4c5c8 + c14c12c10\alpha c3c6 + \alpha c10c12c16c3c6 + \alpha c10c12c3c5c6 - \alpha c10c12c3c5w1 + \alpha c11c3c5c9\psi2 \\
& + \alpha c13c2c5c8w2 + \alpha c14c3c6c9\psi2 + \alpha c15c2c5c8\psi2 + \alpha c13c14c3c6c9 + \alpha c13c16c3c6c9 + \alpha c13c3c5c6c9 - \alpha c13c3c5c9w1) _Z) c13c14c3c6c9 \\
& + c7n2 \text{RootOf}((c10c11c3c5c8w2 - c10c14c15c3c6c8 + c10c14c3c6c8w2 - c10c15c16c3c6c8 - c10c15c3c5c6c8 + c10c15c3c5c8w1) _Z^2 - \alpha^2 c12c2c5\psi2 \\
& - \alpha c10c12c14c2\sigma1 - \alpha c10c12c14c3c4 - \alpha c10c12c16c2\sigma1 - \alpha c10c12c16c3c4 - \alpha c10c12c2c5\psi1 - \alpha c10c12c2c5\sigma1 - \alpha c10c12c3c4c5 - \alpha c13c14c2c9\sigma1 \\
& - \alpha c13c14c3c4c9 - \alpha c13c16c2c9\sigma1 - \alpha c13c16c3c4c9 - \alpha c13c2c5c9\psi1 - \alpha c13c2c5c9\sigma1 - \alpha c13c3c4c5c9 - \alpha c14c2c9\psi2\sigma1 - \alpha c14c3c4c9\psi2 + (\\
& -c10c14c2c8\sigma1w2 - c10c14c3c4c8w2 + c10c14c15c2c8\sigma1 + c10c14c15c3c4c8 + c10c15c16c2c8\sigma1 + c10c15c16c3c4c8 + c10c15c2c5c8\psi1 + c10c15c2c5c8\sigma1 \\
& + c10c15c3c4c5c8 + c14c12c10\alpha c3c6 + \alpha c10c12c16c3c6 + \alpha c10c12c3c5c6 - \alpha c10c12c3c5w1 + \alpha c11c3c5c9\psi2 + \alpha c13c2c5c8w2 + \alpha c14c3c6c9\psi2 \\
& + \alpha c15c2c5c8\psi2 + \alpha c13c14c3c6c9 + \alpha c13c16c3c6c9 + \alpha c13c3c5c6c9 - \alpha c13c3c5c9w1) _Z) c13c16c3c6c9 - c7\gamma^2 c13c3c4c9w2 - c7\gamma^2 c13c2c9\sigma1w2 \\
& - c7\gamma^2 c10c12c3c4w2 - c7\gamma^2 c10c12c2\sigma1w2 - c7n2\alpha c12c2c5\psi2 - c7n2c10c12c14c2\sigma1 - c7n2c10c12c14c3c4 - c7n2c10c12c16c2\sigma1 - c7n2c10c12c16c3c4 \\
& - c7n2c10c12c2c5\psi1 - c7n2c10c12c2c5\sigma1 - c7n2c10c12c3c4c5 - c7n2c13c14c2c9\sigma1 - c7n2c13c14c3c4c9 - c7n2c13c16c2c9\sigma1 - c7n2c13c16c3c4c9 \\
& - c7n2c13c2c5c9\psi1 - c7n2c13c2c5c9\sigma1 - c7n2c13c3c4c5c9 - c7n2c14c2c9\psi2\sigma1 - c7n2c14c3c4c9\psi2 - \alpha\gamma c15c3c4c9\psi2 - \alpha\gamma c15c2c9\psi2\sigma1 \\
& - \alpha\gamma c13c3c4c9w2 - \alpha\gamma c13c2c9\sigma1w2 - \alpha\gamma c10c12c3c4w2 - \alpha\gamma c10c12c2\sigma1w2 - c7\gamma^2 c13c3c4c9\psi2 - c7\gamma^2 c13c2c9\psi2\sigma1)), S1=1/ \\
& (\text{RootOf}((c10c11c3c5c8w2 - c10c14c15c3c6c8 + c10c14c3c6c8w2 - c10c15c16c3c6c8 - c10c15c3c5c6c8 + c10c15c3c5c8w1) _Z^2 - \alpha^2 c12c2c5\psi2 \\
& - \alpha c10c12c14c2\sigma1 - \alpha c10c12c14c3c4 - \alpha c10c12c16c2\sigma1 - \alpha c10c12c16c3c4 - \alpha c10c12c2c5\psi1 - \alpha c10c12c2c5\sigma1 - \alpha c10c12c3c4c5 - \alpha c13c14c2c9\sigma1 \\
& - \alpha c13c14c3c4c9 - \alpha c13c16c2c9\sigma1 - \alpha c13c16c3c4c9 - \alpha c13c2c5c9\psi1 - \alpha c13c2c5c9\sigma1 - \alpha c13c3c4c5c9 - \alpha c14c2c9\psi2\sigma1 - \alpha c14c3c4c9\psi2 + (\\
& -c10c14c2c8\sigma1w2 - c10c14c3c4c8w2 + c10c14c15c2c8\sigma1 + c10c14c15c3c4c8 + c10c15c16c2c8\sigma1 + c10c15c16c3c4c8 + c10c15c2c5c8\psi1 + c10c15c2c5c8\sigma1 \\
& + c10c15c3c4c5c8 + c14c12c10\alpha c3c6 + \alpha c10c12c16c3c6 + \alpha c10c12c3c5c6 - \alpha c10c12c3c5w1 + \alpha c11c3c5c9\psi2 + \alpha c13c2c5c8w2 + \alpha c14c3c6c9\psi2 \\
& + \alpha c15c2c5c8\psi2 + \alpha c13c14c3c6c9 + \alpha c13c16c3c6c9 + \alpha c13c3c5c6c9 - \alpha c13c3c5c9w1) _Z), S2=\alpha/(\text{RootOf}((c10c11c3c5c8w2 - c10c14c15c3c6c8 \\
& + c10c14c3c6c8w2 - c10c15c16c3c6c8 - c10c15c3c5c6c8 + c10c15c3c5c8w1) _Z^2 - \alpha^2 c12c2c5\psi2 - \alpha c10c12c14c2\sigma1 - \alpha c10c12c14c3c4 - \alpha c10c12c16c2\sigma1 \\
& - \alpha c10c12c16c3c4 - \alpha c10c12c2c5\psi1 - \alpha c10c12c2c5\sigma1 - \alpha c10c12c3c4c5 - \alpha c13c14c2c9\sigma1 - \alpha c13c14c3c4c9 - \alpha c13c16c2c9\sigma1 - \alpha c13c16c3c4c9 \\
& - \alpha c13c2c5c9\psi1 - \alpha c13c2c5c9\sigma1 - \alpha c13c3c4c5c9 - \alpha c14c2c9\psi2\sigma1 - \alpha c14c3c4c9\psi2 + (-c10c14c2c8\sigma1w2 - c10c14c3c4c8w2 + c10c14c15c2c8\sigma1 \\
& + c10c14c15c3c4c8 + c10c15c16c2c8\sigma1 + c10c15c16c3c4c8 + c10c15c2c5c8\psi1 + c10c15c2c5c8\sigma1 + c10c15c3c4c5c8 + c14c12c10\alpha c3c6 + \alpha c10c12c16c3c6 \\
& + \alpha c10c12c3c5c6 - \alpha c10c12c3c5w1 + \alpha c11c3c5c9\psi2 + \alpha c13c2c5c8w2 + \alpha c14c3c6c9\psi2 + \alpha c15c2c5c8\psi2 + \alpha c13c14c3c6c9 + \alpha c13c16c3c6c9 \\
& + \alpha c13c3c5c6c9 - \alpha c13c3c5c9w1) _Z) c8), T=\frac{1}{c5c1c3} (k(\text{RootOf}((c10c11c3c5c8w2 - c10c14c15c3c6c8 + c10c14c3c6c8w2 - c10c15c16c3c6c8 \\
& - c10c15c3c5c6c8 + c10c15c3c5c8w1) _Z^2 - \alpha^2 c12c2c5\psi2 - \alpha c10c12c14c2\sigma1 - \alpha c10c12c14c3c4 - \alpha c10c12c16c2\sigma1 - \alpha c10c12c16c3c4 - \alpha c10c12c2c5\psi1 \\
& - \alpha c10c12c2c5\sigma1 - \alpha c10c12c3c4c5 - \alpha c13c14c2c9\sigma1 - \alpha c13c14c3c4c9 - \alpha c13c16c2c9\sigma1 - \alpha c13c16c3c4c9 - \alpha c13c2c5c9\psi1 - \alpha c13c2c5c9\sigma1 \\
& - \alpha c13c3c4c5c9 - \alpha c14c2c9\psi2\sigma1 - \alpha c14c3c4c9\psi2 + (-c10c14c2c8\sigma1w2 - c10c14c3c4c8w2 + c10c14c15c2c8\sigma1 + c10c14c15c3c4c8 + c10c15c16c2c8\sigma1 \\
& + c10c15c16c3c4c8 + c10c15c2c5c8\psi1 + c10c15c2c5c8\sigma1 + c10c15c3c4c5c8 + c14c12c10\alpha c3c6 + \alpha c10c12c16c3c6 + \alpha c10c12c3c5c6 - \alpha c10c12c3c5w1 \\
& + \alpha c11c3c5c9\psi2 + \alpha c13c2c5c8w2 + \alpha c14c3c6c9\psi2 + \alpha c15c2c5c8\psi2 + \alpha c13c14c3c6c9 + \alpha c13c16c3c6c9 + \alpha c13c3c5c6c9 - \alpha c13c3c5c9w1) _Z) c3c6 - c2\sigma1 \\
& - c4c3)))
\end{aligned}$$

2. Bilangan Reproduksi Dasar dengan Maple 16

with(linalg):

$$F := \begin{bmatrix} 0 & x1\beta & 0 & x1\beta\epsilon \\ 0 & x2\beta & 0 & x2\beta\epsilon \\ 0 & x3\beta & 0 & x3\beta\epsilon \\ 0 & x4\beta & 0 & x4\beta\epsilon \end{bmatrix} :$$

$$V := \begin{bmatrix} y1 & 0 & 0 & 0 \\ -\sigma1 & y2 & 0 & 0 \\ -\alpha & 0 & y3 & 0 \\ 0 & -(\tau\alpha) & -(\theta\sigma2) & y4 \end{bmatrix} :$$

> M := inverse(V)

$$M := \begin{bmatrix} \frac{1}{y1} & 0 & 0 & 0 \\ \frac{\sigma1}{y1y2} & \frac{1}{y2} & 0 & 0 \\ \frac{\alpha}{y1y3} & 0 & \frac{1}{y3} & 0 \\ \frac{\alpha(\sigma1\tau y3 + \sigma2\theta y2)}{y1y2y3y4} & \frac{\tau\alpha}{y2y4} & \frac{\theta\sigma2}{y3y4} & \frac{1}{y4} \end{bmatrix} \quad (1)$$

> evalm(F&*M)

$$\begin{bmatrix} \frac{x1\beta\sigma1}{y1y2} + \frac{x1\beta\epsilon\alpha(\sigma1\tau y3 + \sigma2\theta y2)}{y1y2y3y4} & \frac{x1\beta}{y2} + \frac{x1\beta\epsilon\tau\alpha}{y2y4} & \frac{x1\beta\epsilon\theta\sigma2}{y3y4} & \frac{x1\beta\epsilon}{y4} \\ \frac{x2\beta\sigma1}{y1y2} + \frac{x2\beta\epsilon\alpha(\sigma1\tau y3 + \sigma2\theta y2)}{y1y2y3y4} & \frac{x2\beta}{y2} + \frac{x2\beta\epsilon\tau\alpha}{y2y4} & \frac{x2\beta\epsilon\theta\sigma2}{y3y4} & \frac{x2\beta\epsilon}{y4} \\ \frac{x3\beta\sigma1}{y1y2} + \frac{x3\beta\epsilon\alpha(\sigma1\tau y3 + \sigma2\theta y2)}{y1y2y3y4} & \frac{x3\beta}{y2} + \frac{x3\beta\epsilon\tau\alpha}{y2y4} & \frac{x3\beta\epsilon\theta\sigma2}{y3y4} & \frac{x3\beta\epsilon}{y4} \\ \frac{x4\beta\sigma1}{y1y2} + \frac{x4\beta\epsilon\alpha(\sigma1\tau y3 + \sigma2\theta y2)}{y1y2y3y4} & \frac{x4\beta}{y2} + \frac{x4\beta\epsilon\tau\alpha}{y2y4} & \frac{x4\beta\epsilon\theta\sigma2}{y3y4} & \frac{x4\beta\epsilon}{y4} \end{bmatrix} \quad (2)$$

> hsl := evalm(F&*M)

$$hsl := \begin{bmatrix} \frac{x1\beta\sigma1}{y1y2} + \frac{x1\beta\epsilon\alpha(\sigma1\tau y3 + \sigma2\theta y2)}{y1y2y3y4} & \frac{x1\beta}{y2} + \frac{x1\beta\epsilon\tau\alpha}{y2y4} & \frac{x1\beta\epsilon\theta\sigma2}{y3y4} & \frac{x1\beta\epsilon}{y4} \\ \frac{x2\beta\sigma1}{y1y2} + \frac{x2\beta\epsilon\alpha(\sigma1\tau y3 + \sigma2\theta y2)}{y1y2y3y4} & \frac{x2\beta}{y2} + \frac{x2\beta\epsilon\tau\alpha}{y2y4} & \frac{x2\beta\epsilon\theta\sigma2}{y3y4} & \frac{x2\beta\epsilon}{y4} \\ \frac{x3\beta\sigma1}{y1y2} + \frac{x3\beta\epsilon\alpha(\sigma1\tau y3 + \sigma2\theta y2)}{y1y2y3y4} & \frac{x3\beta}{y2} + \frac{x3\beta\epsilon\tau\alpha}{y2y4} & \frac{x3\beta\epsilon\theta\sigma2}{y3y4} & \frac{x3\beta\epsilon}{y4} \\ \frac{x4\beta\sigma1}{y1y2} + \frac{x4\beta\epsilon\alpha(\sigma1\tau y3 + \sigma2\theta y2)}{y1y2y3y4} & \frac{x4\beta}{y2} + \frac{x4\beta\epsilon\tau\alpha}{y2y4} & \frac{x4\beta\epsilon\theta\sigma2}{y3y4} & \frac{x4\beta\epsilon}{y4} \end{bmatrix} \quad (3)$$

$$i := \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} :$$

> λ:i:

> evalm(hsl - (λ:i))

$$\begin{bmatrix} \frac{x1\beta\sigma1}{y1y2} + \frac{x1\beta\epsilon\alpha(\sigma1\tau y3 + \sigma2\theta y2)}{y1y2y3y4} - \lambda & \frac{x1\beta}{y2} + \frac{x1\beta\epsilon\tau\alpha}{y2y4} & \frac{x1\beta\epsilon\theta\sigma2}{y3y4} & \frac{x1\beta\epsilon}{y4} \\ \frac{x2\beta\sigma1}{y1y2} + \frac{x2\beta\epsilon\alpha(\sigma1\tau y3 + \sigma2\theta y2)}{y1y2y3y4} & \frac{x2\beta}{y2} + \frac{x2\beta\epsilon\tau\alpha}{y2y4} - \lambda & \frac{x2\beta\epsilon\theta\sigma2}{y3y4} & \frac{x2\beta\epsilon}{y4} \\ \frac{x3\beta\sigma1}{y1y2} + \frac{x3\beta\epsilon\alpha(\sigma1\tau y3 + \sigma2\theta y2)}{y1y2y3y4} & \frac{x3\beta}{y2} + \frac{x3\beta\epsilon\tau\alpha}{y2y4} & \frac{x3\beta\epsilon\theta\sigma2}{y3y4} - \lambda & \frac{x3\beta\epsilon}{y4} \\ \frac{x4\beta\sigma1}{y1y2} + \frac{x4\beta\epsilon\alpha(\sigma1\tau y3 + \sigma2\theta y2)}{y1y2y3y4} & \frac{x4\beta}{y2} + \frac{x4\beta\epsilon\tau\alpha}{y2y4} & \frac{x4\beta\epsilon\theta\sigma2}{y3y4} & \frac{x4\beta\epsilon}{y4} - \lambda \end{bmatrix} \quad (4)$$

> det(evalm(hsl - (λ:i))) = 0

$$-\lambda^3 (\alpha\beta\epsilon\sigma1\tau x1y3 + \alpha\beta\epsilon\sigma2\theta x1y2 + \alpha\beta\epsilon\tau x2y1y3 + \beta\epsilon\sigma2\theta x3y1y2 - \lambda y1y2y3y4 + \beta\epsilon x4y1y2y3 + x1\beta\sigma1y3y4 + \beta x2y1y3y4) = 0 \quad (5)$$

> solve({(5)}, [λ])

$$\left[\lambda = 0, [\lambda = 0], [\lambda = 0], \lambda = \frac{\beta(\alpha\epsilon\sigma1\tau x1y3 + \alpha\epsilon\sigma2\theta x1y2 + \alpha\epsilon\tau x2y1y3 + \epsilon\sigma2\theta x3y1y2 + \epsilon x4y1y2y3 + \sigma1x1y3y4 + x2y1y3y4)}{y1y2y3y4} \right] \quad (6)$$

> lambda = beta*(alpha*epsilon*sigma1*tau*x1*y3+alpha*epsilon*sigma2*theta*x1*y2+alpha*epsilon*tau*x2*y1*y3+epsilon*sigma2*theta*x3*y1*y2+epsilon*x4*y1*y2*y3+sigma1*x1*y3*y4+x2*y1*y3*y4)/(y1*y2*y3*y4)

$$\lambda = \frac{\beta(\alpha\epsilon\sigma1\tau x1y3 + \alpha\epsilon\sigma2\theta x1y2 + \alpha\epsilon\tau x2y1y3 + \epsilon\sigma2\theta x3y1y2 + \epsilon x4y1y2y3 + \sigma1x1y3y4 + x2y1y3y4)}{y1y2y3y4} \quad (7)$$

> simplify((7), 'size')

$$\lambda = \frac{(((\alpha\tau x2 + x4y2)y1 + x1\alpha\sigma1\tau)\epsilon + y4(\sigma1x1 + x2y1))y3 + \theta\sigma2\epsilon y2(\alpha x1 + x3y1)\beta}{y1y2y3y4} \quad (8)$$

3. Sensitivitas dengan Normalized Sensitivity Index dengan Maple 16

```

restart
> #sensitivity index terhadap beta
R := 
$$\frac{\beta \cdot (\alpha \cdot e \cdot d1 \cdot \tau \cdot x1 \cdot y3 + \alpha \cdot e \cdot \sigma2 \cdot \theta \cdot x1 \cdot y2 + \alpha \cdot e \cdot \tau \cdot x2 \cdot y1 \cdot y3 + e \cdot \sigma2 \cdot \theta \cdot x3 \cdot y1 \cdot y2 + e \cdot x4 \cdot y1 \cdot y2 \cdot y3 + d1 \cdot x1 \cdot y3 \cdot y4 + x2 \cdot y1 \cdot y3 \cdot y4)}{y1 \cdot y2 \cdot y3 \cdot y4}$$


$$\frac{\beta (\alpha e d1 \tau x1 y3 + \alpha e \sigma2 \theta x1 y2 + \alpha e \tau x2 y1 y3 + e \sigma2 \theta x3 y1 y2 + e x4 y1 y2 y3 + d1 x1 y3 y4 + x2 y1 y3 y4)}{y1 y2 y3 y4}$$

diff(R, beta)

$$\frac{\alpha e d1 \tau x1 y3 + \alpha e \sigma2 \theta x1 y2 + \alpha e \tau x2 y1 y3 + e \sigma2 \theta x3 y1 y2 + e x4 y1 y2 y3 + d1 x1 y3 y4 + x2 y1 y3 y4}{y1 y2 y3 y4}$$

> 
$$\left( \frac{\alpha e d1 \tau x1 y3 + \alpha e \sigma2 \theta x1 y2 + \alpha e \tau x2 y1 y3 + e \sigma2 \theta x3 y1 y2 + e x4 y1 y2 y3 + d1 x1 y3 y4 + x2 y1 y3 y4}{y1 y2 y3 y4} \right)$$


$$\left( \frac{\beta \cdot (\alpha \cdot e \cdot d1 \cdot \tau \cdot x1 \cdot y3 + \alpha \cdot e \cdot \sigma2 \cdot \theta \cdot x1 \cdot y2 + \alpha \cdot e \cdot \tau \cdot x2 \cdot y1 \cdot y3 + e \cdot \sigma2 \cdot \theta \cdot x3 \cdot y1 \cdot y2 + e \cdot x4 \cdot y1 \cdot y2 \cdot y3 + d1 \cdot x1 \cdot y3 \cdot y4 + x2 \cdot y1 \cdot y3 \cdot y4)}{y1 \cdot y2 \cdot y3 \cdot y4} \right)$$

1

```

4. Perubahan parameter kontak infeksi TB aktif yang terkena DM dengan $\beta=4, \beta=3, \beta=2$.

```

> restart;
> with(linalg): with(plots): with(DEtools):
>
> beta := 4; sigma1 := 0.05; sigma2 := 0.7; theta := 2; tau := 1.01; alpha := 0.3; p1 := 0.3; p2 := 0.6; mu := 1.5; d1 := 0.09; d2 := 0.10; q := 0.15; psi := 0.7; psi2 := 0.9; w1 := 0.55;
w2 := 0.65; delta1 := 0.91; delta2 := 1; n1 := 0.25; n2 := 0.55; e := 0.8806;
> x1 := (1 - p1) * (mu / (alpha + mu)); x2 := p1 * (mu / (alpha + mu)); x3 := theta * (1 - p2) * (alpha / (alpha + mu)); x4 := theta * p2 * (alpha / (alpha + mu)); y1 := (alpha + mu + sigma1 + psi); y2 := (mu + d1 - tau * alpha - w1 - n1);
y3 := (mu + theta * sigma2 + psi2); y4 := (mu + d2 + w2 + n2);
> R0 := 
$$\frac{\beta \cdot (\alpha \cdot d1 \cdot \tau \cdot x1 \cdot y3 + \alpha \cdot \sigma2 \cdot \theta \cdot x1 \cdot y2 + \alpha \cdot \tau \cdot x2 \cdot y1 \cdot y3 + \sigma2 \cdot \theta \cdot x3 \cdot y1 \cdot y2 + x4 \cdot y1 \cdot y2 \cdot y3 + d1 \cdot x1 \cdot y3 \cdot y4 + x2 \cdot y1 \cdot y3 \cdot y4)}{y1 \cdot y2 \cdot y3 \cdot y4}$$
;
>
> lambda22 := beta * (i1(t) + e * i2(t));
> T1 := 
$$\frac{d}{dt} s1(t) = \mu - (\alpha + \mu + \lambda22) \cdot s1(t)$$
;
> T2 := 
$$\frac{d}{dt} e1(t) = (1 - p1) \cdot \lambda22 \cdot s1(t) - (\alpha + \mu + \sigma1 + \psi1) \cdot e1(t)$$
;
> T3 := 
$$\frac{d}{dt} i1(t) = p1 \cdot \lambda22 \cdot s1(t) + \sigma1 \cdot e1(t) + (1 - q) \cdot \delta1 \cdot TR(t) - (\mu + d1 + \tau \cdot \alpha + w1 + n1) \cdot i1(t)$$
;
> T4 := 
$$\frac{d}{dt} r1(t) = n1 \cdot i1(t) + q \cdot \sigma1 \cdot TR(t) - (\alpha + \mu) \cdot r1(t)$$
;
> T5 := 
$$\frac{d}{dt} s2(t) = \alpha \cdot s1(t) - (\mu + \theta \cdot \lambda22) \cdot s2(t)$$
;
> T6 := 
$$\frac{d}{dt} e2(t) = \alpha \cdot e1(t) + \theta \cdot (1 - p2) \cdot \lambda22 \cdot s2(t) - (\mu + \theta \cdot \sigma2 + \psi2) \cdot e2(t)$$
;
> T7 := 
$$\frac{d}{dt} i2(t) = \tau \cdot \alpha \cdot i1(t) + \theta \cdot p2 \cdot \lambda22 \cdot s2(t) + \theta \cdot \sigma2 \cdot e2(t) + \theta \cdot (1 - q) \cdot \delta2 \cdot TR(t) - (\mu + d2 + w2 + n2) \cdot i2(t)$$
;
> T8 := 
$$\frac{d}{dt} r2(t) = \alpha \cdot r1(t) + n2 \cdot i2(t) + q \cdot \delta2 \cdot TR(t) - \mu \cdot r2(t)$$
;
> T9 := 
$$\frac{d}{dt} TR(t) = w1 \cdot i1(t) + w2 \cdot i2(t) + \psi1 \cdot e1(t) + \psi2 \cdot e2(t) - \mu \cdot TR(t)$$
;
>
> s11 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..10, i1 = 0..10, r1 = 0..10, s2 = 0..10, e2 = 0..10, i2 = 0..10, r2 = 0..10, TR = 0..10, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linecolor = [magenta], arrows = medium, scene = [t, s1(t)]);
> s21 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..10, i1 = 0..10, r1 = 0..10, s2 = 0..0.2, e2 = 0..1, i2 = 0..1, r2 = 0..1, TR = 0..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linecolor = [magenta], arrows = medium, scene = [t, s2(t)]);
> e11 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..0.07, i1 = 0..1, r1 = 0..1, s2 = 0..1, e2 = 0..1, i2 = 0..1, r2 = 0..1, TR = 0..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linecolor = [magenta], arrows = medium, scene = [t, e1(t)]);
> e21 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..1, i1 = 0..1, r1 = 0..1, s2 = 0..0.2, e2 = 0..0.07, i2 = 0..1, r2 = 0..1, TR = 0..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linecolor = [magenta], arrows = medium, scene = [t, e2(t)]);
> i11 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..1, i1 = 0..0.05, r1 = 0..1, s2 = 0..1, e2 = 0..1, i2 = 0..1, r2 = 0..1, TR = 0..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linecolor = [magenta], arrows = medium, scene = [t, i1(t)]);
> i21 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..1, i1 = 0..1, r1 = 0..1, s2 = 0..1, e2 = 0..1, i2 = 0..0.05, r2 = 0..1, TR = 0..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linecolor = [magenta], arrows = medium, scene = [t, i2(t)]);
> r11 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..1, i1 = 0..1, r1 = 0..0.05, s2 = 0..1, e2 = 0..1, i2 = 0..1, r2 = 0..1, TR = 0..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linecolor = [magenta], arrows = medium, scene = [t, r1(t)]);
> r21 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..1, i1 = 0..1, r1 = 0..1, s2 = 0..1, e2 = 0..1, i2 = 0..1, r2 = 0..0.1, TR = 0..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linecolor = [magenta], arrows = medium, scene = [t, r2(t)]);
> TR1 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..1, i1 = 0..1, r1 = 0..1, s2 = 0..1, e2 = 0..1, i2 = 0..1, r2 = 0..1, TR = 0.02..0.1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linecolor = [magenta], arrows = medium, scene = [t, TR(t)]);

```



```

> beta := 3; c1 := 0.05; c2 := 0.7; theta := 2; tau := 1.01; alpha := 0.3; p1 := 0.3; p2 := 0.6; mu := 1.5; d1 := 0.09; d2 := 0.10; q := 0.15; w1 := 0.7; w2 := 0.9; wI := 0.55;
w2 := 0.65; delta := 0.91; delta2 := 1; n1 := 0.25; n2 := 0.55; e := 0.8806;
> x1 := (1 - p1) * (mu / (alpha + mu)); x2 := p1 * (mu / (alpha + mu)); x3 := theta * (1 - p2) * (alpha / (alpha + mu)); x4 := theta * p2 * (alpha / (alpha + mu)); y1 := (alpha + mu + c1 + w1); y2 := (mu + d1 - tau * alpha - wI - n1);
y3 := (mu + theta * c2 + w2); y4 := (mu + d2 + w2 + n2);
> R0 := (alpha * c1 * tau * x1 * y3 + alpha * c2 * theta * x1 * y2 + alpha * tau * x2 * y1 * y3 + c2 * theta * x3 * y1 * y2 + x4 * y1 * y2 * y3 + c1 * x1 * y3 * y4 + x2 * y1 * y3 * y4) /
y1 * y2 * y3 * y4;
>
> lambda22 := beta * (i1(t) + e * i2(t));
> T1 := d/dt s1(t) = mu - (alpha + mu + lambda22) * s1(t);
>
> T2 := d/dt e1(t) = (1 - p1) * lambda22 * s1(t) - (alpha + mu + c1 + w1) * e1(t);
>
> T3 := d/dt i1(t) = p1 * lambda22 * s1(t) + c1 * e1(t) + (1 - q) * delta * TR(t) - (mu + d1 + tau * alpha + w1 + n1) * i1(t);
>
> T4 := d/dt r1(t) = n1 * i1(t) + q * c1 * TR(t) - (alpha + mu) * r1(t);
>
> T5 := d/dt s2(t) = alpha * s1(t) - (mu + theta * lambda22) * s2(t);
>
> T6 := d/dt e2(t) = alpha * e1(t) + theta * (1 - p2) * lambda22 * s2(t) - (mu + theta * c2 + w2) * e2(t);
>
> T7 := d/dt i2(t) = tau * alpha * i1(t) + theta * p2 * lambda22 * s2(t) + theta * c2 * e2(t) + theta * (1 - q) * delta2 * TR(t) - (mu + d2 + w2 + n2) * i2(t);
>
> T8 := d/dt r2(t) = alpha * r1(t) + n2 * i2(t) + q * delta2 * TR(t) - mu * r2(t);
>
> T9 := d/dt TR(t) = w1 * i1(t) + w2 * i2(t) + w1 * e1(t) + w2 * e2(t) - mu * TR(t);
>
> s12 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..10, i1 = 0..10, r1 = 0..10, s2 = 0..10,
e2 = 0..10, i2 = 0..10, r2 = 0..10, TR = 0..10, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06,
TR(0) = 0.05]], linecolor = [blue], arrows = medium, scene = [t, s1(t)]);
>
> s22 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..10, i1 = 0..10, r1 = 0..10, s2 = 0..0.2,
e2 = 0..1, i2 = 0..1, r2 = 0..1, TR = 0..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) =
0.05]], linecolor = [blue], arrows = medium, scene = [t, s2(t)]);
>
> e12 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..0.07, i1 = 0..1, r1 = 0..1, s2 = 0..1, e2 =
0..1, i2 = 0..1, r2 = 0..1, TR = 0..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) =
0.05]], linecolor = [blue], arrows = medium, scene = [t, e1(t)]);
>
> e22 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..1, i1 = 0..1, r1 = 0..1, s2 = 0..0.2, e2 =
0..0.07, i2 = 0..1, r2 = 0..1, TR = 0..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) =
0.05]], linecolor = [blue], arrows = medium, scene = [t, e2(t)]);
>
> i12 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..1, i1 = 0..0.05, r1 = 0..1, s2 = 0..1, e2 =
0..1, i2 = 0..1, r2 = 0..1, TR = 0..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) =
0.05]], linecolor = [blue], arrows = medium, scene = [t, i1(t)]);
>
> i22 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..1, i1 = 0..1, r1 = 0..1, s2 = 0..1, e2 = 0..1,
i2 = 0..0.05, r2 = 0..1, TR = 0..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) =
0.05]], linecolor = [blue], arrows = medium, scene = [t, i2(t)]);
>
> r12 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..1, i1 = 0..1, r1 = 0..0.05, s2 = 0..1, e2 =
0..1, i2 = 0..1, r2 = 0..1, TR = 0..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) =
0.05]], linecolor = [blue], arrows = medium, scene = [t, r1(t)]);
>
> r22 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..1, i1 = 0..1, r1 = 0..1, s2 = 0..1, e2 = 0..1,
i2 = 0..1, r2 = 0..0.1, TR = 0..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) =
0.05]], linecolor = [blue], arrows = medium, scene = [t, r2(t)]);
>
> TR2 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..1, i1 = 0..1, r1 = 0..1, s2 = 0..1, e2 =
0..1, i2 = 0..1, r2 = 0..1, TR = 0.02..0.1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06,
TR(0) = 0.05]], linecolor = [blue], arrows = medium, scene = [t, TR(t)]);
>
beta := 2; c1 := 0.05; c2 := 0.7; theta := 2; tau := 1.01; alpha := 0.3; p1 := 0.3; p2 := 0.6; mu := 1.5; d1 := 0.09; d2 := 0.10; q := 0.15; w1 := 0.7; w2 := 0.9; wI := 0.55;
w2 := 0.65; delta := 0.91; delta2 := 1; n1 := 0.25; n2 := 0.55; e := 0.8806;
> x1 := (1 - p1) * (mu / (alpha + mu)); x2 := p1 * (mu / (alpha + mu)); x3 := theta * (1 - p2) * (alpha / (alpha + mu)); x4 := theta * p2 * (alpha / (alpha + mu)); y1 := (alpha + mu + c1 + w1); y2 := (mu + d1 - tau * alpha - wI - n1);
y3 := (mu + theta * c2 + w2); y4 := (mu + d2 + w2 + n2);
> R0 := (alpha * c1 * tau * x1 * y3 + alpha * c2 * theta * x1 * y2 + alpha * tau * x2 * y1 * y3 + c2 * theta * x3 * y1 * y2 + x4 * y1 * y2 * y3 + c1 * x1 * y3 * y4 + x2 * y1 * y3 * y4) /
y1 * y2 * y3 * y4;
>
> lambda22 := beta * (i1(t) + e * i2(t));
> T1 := d/dt s1(t) = mu - (alpha + mu + lambda22) * s1(t);
>
> T2 := d/dt e1(t) = (1 - p1) * lambda22 * s1(t) - (alpha + mu + c1 + w1) * e1(t);
>
> T3 := d/dt i1(t) = p1 * lambda22 * s1(t) + c1 * e1(t) + (1 - q) * delta * TR(t) - (mu + d1 + tau * alpha + w1 + n1) * i1(t);
>
> T4 := d/dt r1(t) = n1 * i1(t) + q * c1 * TR(t) - (alpha + mu) * r1(t);
>
> T5 := d/dt s2(t) = alpha * s1(t) - (mu + theta * lambda22) * s2(t);
>
> T6 := d/dt e2(t) = alpha * e1(t) + theta * (1 - p2) * lambda22 * s2(t) - (mu + theta * c2 + w2) * e2(t);
>
> T7 := d/dt i2(t) = tau * alpha * i1(t) + theta * p2 * lambda22 * s2(t) + theta * c2 * e2(t) + theta * (1 - q) * delta2 * TR(t) - (mu + d2 + w2 + n2) * i2(t);
>
> T8 := d/dt r2(t) = alpha * r1(t) + n2 * i2(t) + q * delta2 * TR(t) - mu * r2(t);
>
> T9 := d/dt TR(t) = w1 * i1(t) + w2 * i2(t) + w1 * e1(t) + w2 * e2(t) - mu * TR(t);

```

```

> s13 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..10, i1 = 0..10, r1 = 0..10, s2 = 0..10, e2 = 0..10, i2 = 0..10, r2 = 0..10, TR = 0..10, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linestyle = [red], arrows = medium, scene = [t, s1(t)]:
> s23 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..10, i1 = 0..10, r1 = 0..10, s2 = 0..0.2, e2 = 0..1, i2 = 0..1, r2 = 0..1, TR = 0..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linestyle = [red], arrows = medium, scene = [t, s2(t)]:
> e13 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..0.07, i1 = 0..1, r1 = 0..1, s2 = 0..1, e2 = 0..1, i2 = 0..1, r2 = 0..1, TR = 0..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linestyle = [red], arrows = medium, scene = [t, e1(t)]:
> e23 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..1, i1 = 0..1, r1 = 0..1, s2 = 0..0.2, e2 = 0..0.07, i2 = 0..1, r2 = 0..1, TR = 0..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linestyle = [red], arrows = medium, scene = [t, e2(t)]:
> i13 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..1, i1 = 0..0.05, r1 = 0..1, s2 = 0..1, e2 = 0..1, i2 = 0..1, r2 = 0..1, TR = 0..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linestyle = [red], arrows = medium, scene = [t, i1(t)]:
> i23 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..1, i1 = 0..1, r1 = 0..1, s2 = 0..1, e2 = 0..1, i2 = 0..0.05, r2 = 0..1, TR = 0..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linestyle = [red], arrows = medium, scene = [t, i2(t)]:
> r13 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..1, i1 = 0..1, r1 = 0..0.05, s2 = 0..1, e2 = 0..1, i2 = 0..1, r2 = 0..1, TR = 0..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linestyle = [red], arrows = medium, scene = [t, r1(t)]:
> r23 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..1, i1 = 0..1, r1 = 0..1, s2 = 0..1, e2 = 0..1, i2 = 0..1, r2 = 0..0.1, TR = 0..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linestyle = [red], arrows = medium, scene = [t, r2(t)]:
> TR3 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..1, i1 = 0..1, r1 = 0..1, s2 = 0..1, e2 = 0..1, i2 = 0..1, r2 = 0..1, TR = 0.02..0.1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linestyle = [red], arrows = medium, scene = [t, TR(t)]:

> disp1ay([s11, s12, s13], labels = [t(waktu), Individu rentan Tb tanpa Dm(S1)], labeldirections = [horizontal, vertical]):
> disp1ay([s21, s22, s23], labels = [t(waktu), Individu rentan Tb koefisien Dm(S2)], labeldirections = [horizontal, vertical]):

> disp1ay([e21, e22, e23], labels = [t(waktu), Individu laten Tb dengan Dm(E2)], labeldirections = [horizontal, vertical]):
> disp1ay([e11, e12, e13], labels = [t(waktu), Individu laten Tb tanpa Dm(E1)], labeldirections = [horizontal, vertical]):

> disp1ay([i11, i12, i13], labels = [t(waktu), Individu Tb aktif tanpa Dm(I1)], labeldirections = [horizontal, vertical]):

> disp1ay([i21, i22, i23], labels = [t(waktu), Individu Tb aktif tanpa Dm(I2)], labeldirections = [horizontal, vertical]):

> disp1ay([r11, r12, r13], labels = [t(waktu), Individu sembuh Tb tanpa Dm(R1)], labeldirections = [horizontal, vertical]):

> disp1ay([r21, r22, r23], labels = [t(waktu), Individu sembuh Tb koefisien Dm(R2)], labeldirections = [horizontal, vertical]):

> disp1ay([TR1, TR2, TR3], labels = [t(waktu), Individu dengan treatment DOTs], labeldirections = [horizontal, vertical]):

```

5. Perubahan parameter kontak infeksi TB aktif yang terkena DM dengan $w_1=1$, $w_1=3$, $w_1=5$.

```

> restart:
> with(linalg): with(plots): with(DEtools):
> beta := 0.6: sigma1 := 0.05: sigma2 := 0.7: theta := 2: tau := 1.01: alpha := 0.3: p1 := 0.3: p2 := 0.6: mu := 1.5: d1 := 0.09: d2 := 0.10: q := 0.15: psi1 := 0.7: psi2 := 0.9: w1 := 1:
  w2 := 0.95: delta1 := 0.91: delta2 := 1: n1 := 0.25: n2 := 0.55: epsilon := 0.8806:
> x1 := (1 - p1) * (mu / (alpha + mu)): x2 := p1 * (mu / (alpha + mu)): x3 := theta * (1 - p2) * (alpha / (alpha + mu)): x4 := theta * p2 * (alpha / (alpha + mu)): y1 := (alpha + mu + sigma1 + psi1): y2 := (mu + d1 - tau * alpha - w1 - n1):
  y3 := (mu + theta * sigma2 + psi2): y4 := (mu + d2 + w2 + n2):
> R0 := (beta * (alpha * sigma1 * tau * x1 * y3 + alpha * sigma2 * theta * x1 * y2 + alpha * tau * x2 * y1 * y3 + sigma2 * theta * x3 * y1 * y2 + x4 * y1 * y2 * y3 + sigma1 * x1 * y3 * y4 + x2 * y1 * y3 * y4)) /
  (y1 * y2 * y3 * y4):
>
> lambda22 := beta * (i1(t) + e1(t)):
> T1 := diff(s1(t), t) = mu - (alpha + mu + lambda22) * s1(t):
> T2 := diff(e1(t), t) = (1 - p1) * lambda22 * s1(t) - (alpha + mu + sigma1 + psi1) * e1(t):
> T3 := diff(i1(t), t) = p1 * lambda22 * s1(t) + sigma1 * e1(t) + (1 - q) * delta1 * TR(t) - (mu + d1 + tau * alpha + w1 + n1) * i1(t):
> T4 := diff(r1(t), t) = n1 * i1(t) + q * sigma1 * TR(t) - (alpha + mu) * r1(t):
> T5 := diff(s2(t), t) = alpha * s1(t) - (mu + theta * lambda22) * s2(t):
> T6 := diff(e2(t), t) = alpha * e1(t) + theta * (1 - p2) * lambda22 * s2(t) - (mu + theta * sigma2 + psi2) * e2(t):
> T7 := diff(i2(t), t) = tau * alpha * i1(t) + theta * p2 * lambda22 * s2(t) + theta * sigma2 * e2(t) + theta * (1 - q) * delta2 * TR(t) - (mu + d2 + w2 + n2) * i2(t):
> T8 := diff(r2(t), t) = alpha * r1(t) + n2 * i2(t) + q * delta2 * TR(t) - mu * r2(t):

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T9 :=  $\frac{d}{dt} TR(t) = w_1 \cdot i(t) + w_2 \cdot i_2(t) + \psi_1 \cdot e(t) + \psi_2 \cdot e_2(t) - \mu \cdot TR(t)$  :
s11 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s(t), e(t), i(t), r(t), s_2(t), e_2(t), i_2(t), r_2(t), TR(t)], t=0..10, s1=0..1, e1=0..10, i1=0..10, r1=0..10, s2=0..10, e2=0..10, i2=0..10, r2=0..10, TR=0..10, [[s1(0)=0.1158, e1(0)=0.0589, i1(0)=0.0135, r1(0)=0.03, s2(0)=0.0766, e2(0)=0.0554, i2(0)=0.02, r2(0)=0.06, TR(0)=0.05]], linecolor=[magenta], arrows=medium, scene=[t, s1(t)]) :
s21 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s(t), e(t), i(t), r(t), s_2(t), e_2(t), i_2(t), r_2(t), TR(t)], t=0..10, s1=0..1, e1=0..10, i1=0..10, r1=0..10, s2=0..10, e2=0..10, i2=0..10, r2=0..10, TR=0..10, [[s1(0)=0.1158, e1(0)=0.0589, i1(0)=0.0135, r1(0)=0.03, s2(0)=0.0766, e2(0)=0.0554, i2(0)=0.02, r2(0)=0.06, TR(0)=0.05]], linecolor=[magenta], arrows=medium, scene=[t, s2(t)]) :
e11 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s(t), e(t), i(t), r(t), s_2(t), e_2(t), i_2(t), r_2(t), TR(t)], t=0..10, s1=0..1, e1=0..0.07, i1=0..0.1, r1=0..0.1, s2=0..0.1, e2=0..0.1, i2=0..0.1, r2=0..0.1, TR=0..0.1, [[s1(0)=0.1158, e1(0)=0.0589, i1(0)=0.0135, r1(0)=0.03, s2(0)=0.0766, e2(0)=0.0554, i2(0)=0.02, r2(0)=0.06, TR(0)=0.05]], linecolor=[magenta], arrows=medium, scene=[t, e1(t)]) :
e21 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s(t), e(t), i(t), r(t), s_2(t), e_2(t), i_2(t), r_2(t), TR(t)], t=0..10, s1=0..1, e1=0..0.1, i1=0..0.1, r1=0..0.1, s2=0..0.2, e2=0..0.07, i2=0..0.1, r2=0..0.1, TR=0..0.1, [[s1(0)=0.1158, e1(0)=0.0589, i1(0)=0.0135, r1(0)=0.03, s2(0)=0.0766, e2(0)=0.0554, i2(0)=0.02, r2(0)=0.06, TR(0)=0.05]], linecolor=[magenta], arrows=medium, scene=[t, e2(t)]) :
i11 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s(t), e(t), i(t), r(t), s_2(t), e_2(t), i_2(t), r_2(t), TR(t)], t=0..10, s1=0..1, e1=0..0.1, i1=0..0.05, r1=0..0.1, s2=0..0.1, e2=0..0.1, i2=0..0.1, r2=0..0.1, TR=0..0.1, [[s1(0)=0.1158, e1(0)=0.0589, i1(0)=0.0135, r1(0)=0.03, s2(0)=0.0766, e2(0)=0.0554, i2(0)=0.02, r2(0)=0.06, TR(0)=0.05]], linecolor=[magenta], arrows=medium, scene=[t, i1(t)]) :
i21 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s(t), e(t), i(t), r(t), s_2(t), e_2(t), i_2(t), r_2(t), TR(t)], t=0..10, s1=0..1, e1=0..0.1, i1=0..0.1, s2=0..0.1, e2=0..0.1, i2=0..0.05, r2=0..0.1, TR=0..0.1, [[s1(0)=0.1158, e1(0)=0.0589, i1(0)=0.0135, r1(0)=0.03, s2(0)=0.0766, e2(0)=0.0554, i2(0)=0.02, r2(0)=0.06, TR(0)=0.05]], linecolor=[magenta], arrows=medium, scene=[t, i2(t)]) :
r11 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s(t), e(t), i(t), r(t), s_2(t), e_2(t), i_2(t), r_2(t), TR(t)], t=0..10, s1=0..1, e1=0..0.1, i1=0..0.1, r1=0..0.05, s2=0..0.1, e2=0..0.1, i2=0..0.1, r2=0..0.1, TR=0..0.1, [[s1(0)=0.1158, e1(0)=0.0589, i1(0)=0.0135, r1(0)=0.03, s2(0)=0.0766, e2(0)=0.0554, i2(0)=0.02, r2(0)=0.06, TR(0)=0.05]], linecolor=[magenta], arrows=medium, scene=[t, r1(t)]) :
r21 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s(t), e(t), i(t), r(t), s_2(t), e_2(t), i_2(t), r_2(t), TR(t)], t=0..10, s1=0..1, e1=0..0.1, i1=0..0.1, r1=0..0.1, s2=0..0.1, e2=0..0.1, i2=0..0.1, r2=0..0.1, TR=0..0.1, [[s1(0)=0.1158, e1(0)=0.0589, i1(0)=0.0135, r1(0)=0.03, s2(0)=0.0766, e2(0)=0.0554, i2(0)=0.02, r2(0)=0.06, TR(0)=0.05]], linecolor=[magenta], arrows=medium, scene=[t, r2(t)]) :
TR1 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s(t), e(t), i(t), r(t), s_2(t), e_2(t), i_2(t), r_2(t), TR(t)], t=0..10, s1=0..1, e1=0..0.1, i1=0..0.1, r1=0..0.1, s2=0..0.1, e2=0..0.1, i2=0..0.1, r2=0..0.1, TR=0.02..0.1, [[s1(0)=0.1158, e1(0)=0.0589, i1(0)=0.0135, r1(0)=0.03, s2(0)=0.0766, e2(0)=0.0554, i2(0)=0.02, r2(0)=0.06, TR(0)=0.05]], linecolor=[magenta], arrows=medium, scene=[t, TR(t)] :
> display([s11], labels=[t(waktu), Individu rentan Tb tanpa Dm(S1)], labeldirections=[horizontal, vertical]) :
> display([s21], labels=[t(waktu), Individu rentan Tb kotifolci Dm(S2)], labeldirections=[horizontal, vertical]) :
> display([e11], labels=[t(waktu), Individu laten Tb tanpa Dm(E1)], labeldirections=[horizontal, vertical]) :
> display([e21], labels=[t(waktu), Individu laten Tb tanpa Dm(E2)], labeldirections=[horizontal, vertical]) :
> display([i11], labels=[t(waktu), Individu laten Tb tanpa Dm(I1)], labeldirections=[horizontal, vertical]) :
> display([i21], labels=[t(waktu), Individu laten Tb tanpa Dm(I2)], labeldirections=[horizontal, vertical]) :
> display([r11], labels=[t(waktu), Individu sembuh Tb kotifolci Dm(R1)], labeldirections=[horizontal, vertical]) :
> display([r21], labels=[t(waktu), Individu sembuh Tb kotifolci Dm(R2)], labeldirections=[horizontal, vertical]) :
> display([TR1], labels=[t(waktu), Individu dengan treatment DOTS], labeldirections=[horizontal, vertical]) :
>  $\beta := 0.7$  :  $\sigma_1 := 0.05$  :  $\sigma_2 := 0.7$  :  $\theta := 2$  :  $\tau := 1.01$  :  $\alpha := 0.3$  :  $p_1 := 0.3$  :  $p_2 := 0.6$  :  $\mu := 1.5$  :  $d_1 := 0.09$  :  $d_2 := 0.10$  :  $q := 0.15$  :  $\psi_1 := 0.7$  :  $\psi_2 := 0.9$  :  $w_1 := \beta$  :  $w_2 := 0.65$  :  $\delta_1 := 0.91$  :  $\delta_2 := 1$  :  $n_1 := 0.25$  :  $n_2 := 0.55$  :  $e := 0.8806$  :
>  $x_1 := (1 - p_1) \cdot \left(\frac{\mu}{\alpha + \mu}\right)$  :  $x_2 := p_1 \cdot \left(\frac{\mu}{\alpha + \mu}\right)$  :  $x_3 := \theta \cdot (1 - p_2) \cdot \left(\frac{\alpha}{\alpha + \mu}\right)$  :  $x_4 := \theta \cdot p_2 \cdot \left(\frac{\alpha}{\alpha + \mu}\right)$  :  $y_1 := (\alpha + \mu + \sigma_1 + \psi_1)$  :  $y_2 := (\mu + d_1 - \tau \cdot \alpha - w_1 - n_1)$  :
>  $y_3 := (\mu + \theta \cdot \sigma_2 + \psi_2)$  :  $y_4 := (\mu + d_2 + w_2 + n_2)$  :
>  $RO := \frac{\beta \cdot (\alpha \cdot \sigma_1 \cdot \tau \cdot x_1 \cdot y_3 + \alpha \cdot \sigma_2 \cdot \theta \cdot x_2 \cdot y_1 \cdot y_3 + \sigma_2 \cdot \theta \cdot x_3 \cdot y_1 \cdot y_2 + x_4 \cdot y_1 \cdot y_2 \cdot y_3 + \sigma_1 \cdot x_1 \cdot y_3 \cdot y_4 + x_2 \cdot y_1 \cdot y_3 \cdot y_4)}{y_1 \cdot y_2 \cdot y_3 \cdot y_4}$  :
>
>  $\lambda_{22} := \beta \cdot (i_1(t) + e \cdot i_2(t))$  :
>  $T1 := \frac{d}{dt} s(t) = \mu - (\alpha + \mu + \lambda_{22}) \cdot s(t)$  :
>  $T2 := \frac{d}{dt} e(t) = (1 - p_1) \cdot \lambda_{22} \cdot s(t) - (\alpha + \mu + \sigma_1 + \psi_1) \cdot e(t)$  :
>  $T3 := \frac{d}{dt} i(t) = p_1 \cdot \lambda_{22} \cdot s(t) + \sigma_1 \cdot e(t) + (1 - q) \cdot \delta_1 \cdot TR(t) - (\mu + d_1 + \tau \cdot \alpha + w_1 + n_1) \cdot i(t)$  :
>  $T4 := \frac{d}{dt} r(t) = n_1 \cdot i(t) + q \cdot \sigma_1 \cdot TR(t) - (\alpha + \mu) \cdot r(t)$  :
>  $T5 := \frac{d}{dt} s_2(t) = \alpha \cdot s(t) - (\mu + \theta \cdot \lambda_{22}) \cdot s_2(t)$  :
>  $T6 := \frac{d}{dt} e_2(t) = \alpha \cdot e(t) + \theta \cdot (1 - p_2) \cdot \lambda_{22} \cdot s_2(t) - (\mu + \theta \cdot \sigma_2 + \psi_2) \cdot e_2(t)$  :
>  $T7 := \frac{d}{dt} i_2(t) = \tau \cdot \alpha \cdot i(t) + \theta \cdot p_2 \cdot \lambda_{22} \cdot s_2(t) + \theta \cdot \sigma_2 \cdot e_2(t) + \theta \cdot (1 - q) \cdot \delta_2 \cdot TR(t) - (\mu + d_2 + w_2 + n_2) \cdot i_2(t)$  :
>  $T8 := \frac{d}{dt} r_2(t) = \alpha \cdot r(t) + n_2 \cdot i_2(t) + q \cdot \delta_2 \cdot TR(t) - \mu \cdot r_2(t)$  :
>  $T9 := \frac{d}{dt} TR(t) = w_1 \cdot i(t) + w_2 \cdot i_2(t) + \psi_1 \cdot e(t) + \psi_2 \cdot e_2(t) - \mu \cdot TR(t)$  :
>  $T9 := \frac{d}{dt} TR(t) = w_1 \cdot i(t) + w_2 \cdot i_2(t) + \psi_1 \cdot e(t) + \psi_2 \cdot e_2(t) - \mu \cdot TR(t)$  :
>
> s11 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s(t), e(t), i(t), r(t), s_2(t), e_2(t), i_2(t), r_2(t), TR(t)], t=0..10, s1=0..1, e1=0..10, i1=0..10, r1=0..10, s2=0..10, e2=0..10, i2=0..10, r2=0..10, TR=0..10, [[s1(0)=0.1158, e1(0)=0.0589, i1(0)=0.0135, r1(0)=0.03, s2(0)=0.0766, e2(0)=0.0554, i2(0)=0.02, r2(0)=0.06, TR(0)=0.05]], linecolor=[blue], arrows=medium, scene=[t, s1(t)]) :
> s21 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s(t), e(t), i(t), r(t), s_2(t), e_2(t), i_2(t), r_2(t), TR(t)], t=0..10, s1=0..1, e1=0..10, i1=0..10, r1=0..10, s2=0..10, e2=0..10, i2=0..10, r2=0..10, TR=0..10, [[s1(0)=0.1158, e1(0)=0.0589, i1(0)=0.0135, r1(0)=0.03, s2(0)=0.0766, e2(0)=0.0554, i2(0)=0.02, r2(0)=0.06, TR(0)=0.05]], linecolor=[blue], arrows=medium, scene=[t, s2(t)]) :
> e11 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s(t), e(t), i(t), r(t), s_2(t), e_2(t), i_2(t), r_2(t), TR(t)], t=0..10, s1=0..1, e1=0..0.07, i1=0..0.1, r1=0..0.1, s2=0..0.1, e2=0..0.1, i2=0..0.1, r2=0..0.1, TR=0..0.1, [[s1(0)=0.1158, e1(0)=0.0589, i1(0)=0.0135, r1(0)=0.03, s2(0)=0.0766, e2(0)=0.0554, i2(0)=0.02, r2(0)=0.06, TR(0)=0.05]], linecolor=[blue], arrows=medium, scene=[t, e1(t)]) :
> e21 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s(t), e(t), i(t), r(t), s_2(t), e_2(t), i_2(t), r_2(t), TR(t)], t=0..10, s1=0..1, e1=0..0.1, i1=0..0.1, r1=0..0.1, s2=0..0.2, e2=0..0.07, i2=0..0.1, r2=0..0.1, TR=0..0.1, [[s1(0)=0.1158, e1(0)=0.0589, i1(0)=0.0135, r1(0)=0.03, s2(0)=0.0766, e2(0)=0.0554, i2(0)=0.02, r2(0)=0.06, TR(0)=0.05]], linecolor=[blue], arrows=medium, scene=[t, e2(t)]) :
> i11 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s(t), e(t), i(t), r(t), s_2(t), e_2(t), i_2(t), r_2(t), TR(t)], t=0..10, s1=0..1, e1=0..0.1, i1=0..0.05, r1=0..0.1, s2=0..0.1, e2=0..0.1, i2=0..0.1, r2=0..0.1, TR=0..0.1, [[s1(0)=0.1158, e1(0)=0.0589, i1(0)=0.0135, r1(0)=0.03, s2(0)=0.0766, e2(0)=0.0554, i2(0)=0.02, r2(0)=0.06, TR(0)=0.05]], linecolor=[blue], arrows=medium, scene=[t, i1(t)]) :
> i21 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s(t), e(t), i(t), r(t), s_2(t), e_2(t), i_2(t), r_2(t), TR(t)], t=0..10, s1=0..1, e1=0..0.1, i1=0..0.1, s2=0..0.1, e2=0..0.1, i2=0..0.05, r2=0..0.1, TR=0..0.1, [[s1(0)=0.1158, e1(0)=0.0589, i1(0)=0.0135, r1(0)=0.03, s2(0)=0.0766, e2(0)=0.0554, i2(0)=0.02, r2(0)=0.06, TR(0)=0.05]], linecolor=[blue], arrows=medium, scene=[t, i2(t)]) :
> r11 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s(t), e(t), i(t), r(t), s_2(t), e_2(t), i_2(t), r_2(t), TR(t)], t=0..10, s1=0..1, e1=0..0.1, i1=0..0.1, r1=0..0.05, s2=0..0.1, e2=0..0.1, i2=0..0.1, r2=0..0.1, TR=0..0.1, [[s1(0)=0.1158, e1(0)=0.0589, i1(0)=0.0135, r1(0)=0.03, s2(0)=0.0766, e2(0)=0.0554, i2(0)=0.02, r2(0)=0.06, TR(0)=0.05]], linecolor=[blue], arrows=medium, scene=[t, r1(t)]) :
> r21 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s(t), e(t), i(t), r(t), s_2(t), e_2(t), i_2(t), r_2(t), TR(t)], t=0..10, s1=0..1, e1=0..0.1, i1=0..0.1, r1=0..0.1, s2=0..0.1, e2=0..0.1, i2=0..0.1, r2=0..0.1, TR=0..0.1, [[s1(0)=0.1158, e1(0)=0.0589, i1(0)=0.0135, r1(0)=0.03, s2(0)=0.0766, e2(0)=0.0554, i2(0)=0.02, r2(0)=0.06, TR(0)=0.05]], linecolor=[blue], arrows=medium, scene=[t, r2(t)]) :
> TR1 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s(t), e(t), i(t), r(t), s_2(t), e_2(t), i_2(t), r_2(t), TR(t)], t=0..10, s1=0..1, e1=0..0.1, i1=0..0.1, r1=0..0.1, s2=0..0.1, e2=0..0.1, i2=0..0.1, r2=0..0.1, TR=0.02..0.1, [[s1(0)=0.1158, e1(0)=0.0589, i1(0)=0.0135, r1(0)=0.03, s2(0)=0.0766, e2(0)=0.0554, i2(0)=0.02, r2(0)=0.06, TR(0)=0.05]], linecolor=[blue], arrows=medium, scene=[t, TR(t)]) :
>
> display([s11], labels=[t(waktu), Individu rentan Tb tanpa Dm(S1)], labeldirections=[horizontal, vertical]) :
> display([s21], labels=[t(waktu), Individu rentan Tb kotifolci Dm(S2)], labeldirections=[horizontal, vertical]) :
> display([e11], labels=[t(waktu), Individu laten Tb tanpa Dm(E1)], labeldirections=[horizontal, vertical]) :
> display([e21], labels=[t(waktu), Individu laten Tb tanpa Dm(E2)], labeldirections=[horizontal, vertical]) :
> display([i11], labels=[t(waktu), Individu laten Tb tanpa Dm(I1)], labeldirections=[horizontal, vertical]) :
> display([i21], labels=[t(waktu), Individu laten Tb tanpa Dm(I2)], labeldirections=[horizontal, vertical]) :
> display([r11], labels=[t(waktu), Individu sembuh Tb kotifolci Dm(R1)], labeldirections=[horizontal, vertical]) :
> display([r21], labels=[t(waktu), Individu sembuh Tb kotifolci Dm(R2)], labeldirections=[horizontal, vertical]) :
> display([TR1], labels=[t(waktu), Individu dengan treatment DOTS], labeldirections=[horizontal, vertical]) :

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> restart:
> with(intalg): with(plots): with(DEtools):
>
> beta := 1: c1 := 0.05: c2 := 0.7: theta := 2: tau := 1.01: alpha := 0.3: p1 := 0.3: p2 := 0.6: mu := 1.5: d1 := 0.09: d2 := 0.10: g := 0.15: psi1 := 0.7: psi2 := 0.9: w1 := 10: w2 := 2: delta1 := 0.91: delta2 := 1:
> n1 := 0.25: n2 := 0.55: e := 0.8806:
> x1 := (1 - p1) * (mu / (alpha + mu)): x2 := p1 * (mu / (alpha + mu)): x3 := theta * (1 - p2) * (alpha / (alpha + mu)): x4 := theta * p2 * (alpha / (alpha + mu)): y1 := (alpha + mu + c1 + psi1): y2 := (mu + d1 - tau * alpha - w1 - n1): y3 := (mu + theta * c2 + psi2): y4 :=
  (mu + d2 - w2 - n2):
> R0 := (alpha * c1 * tau * x1 * y3 + alpha * c2 * theta * x1 * y2 + alpha * tau * x2 * y1 * y3 + c2 * theta * x3 * y1 * y2 + x4 * y1 * y2 * y3 + c1 * x1 * y3 * y4 + x2 * y1 * y3 * y4) /
  (y1 * y2 * y3 * y4)
>
> lambda22 := beta * (i1(t) + e * i2(t)):
> T1 := d/dt s1(t) = mu - (alpha + mu + lambda22) * s1(t):
> T2 := d/dt e1(t) = (1 - p1) * lambda22 * s1(t) - (alpha + mu + c1 + psi1) * e1(t):
> T3 := d/dt i1(t) = p1 * lambda22 * s1(t) + c1 * e1(t) + (1 - g) * delta1 * TR(t) - (mu + d1 + tau * alpha + w1 + n1) * i1(t):
> T4 := d/dt r1(t) = n1 * i1(t) + g * c1 * TR(t) - (alpha + mu) * r1(t):
> T5 := d/dt s2(t) = alpha * s1(t) - (mu + theta * lambda22) * s2(t):
> T6 := d/dt e2(t) = alpha * e1(t) + theta * (1 - p2) * lambda22 * s2(t) - (mu + theta * c2 + psi2) * e2(t):
> T7 := d/dt i2(t) = tau * alpha * i1(t) + theta * p2 * lambda22 * s2(t) + theta * c2 * e2(t) + theta * (1 - g) * delta2 * TR(t) - (mu + d2 + w2 + n2) * i2(t):
> T8 := d/dt r2(t) = alpha * r1(t) + n2 * i2(t) + g * delta2 * TR(t) - mu * r2(t):
> T9 := d/dt TR(t) = w1 * i1(t) + w2 * i2(t) + psi1 * e1(t) + psi2 * e2(t) - mu * TR(t):
>
> s11 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..10, i1 = 0..10, r1 = 0..10, s2 = 0..10, e2 = 0..10, i2 = 0..10, r2 = 0
  ..10, TR = 0..10, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linecolor = [red], arrows = medium, scene = [t,
  s1(t)])
> s21 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..10, i1 = 0..10, r1 = 0..10, s2 = 0..0.2, e2 = 0..1, i2 = 0..1, r2 = 0..1, TR = 0
  ..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linecolor = [red], arrows = medium, scene = [t, s2(t)])
> e11 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..0.07, i1 = 0..1, r1 = 0..1, s2 = 0..1, e2 = 0..1, i2 = 0..1, r2 = 0..1, TR = 0
  ..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linecolor = [red], arrows = medium, scene = [t, e1(t)])
> e21 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..1, r1 = 0..1, s2 = 0..0.2, e2 = 0..0.07, i2 = 0..1, r2 = 0..1, TR = 0
  ..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linecolor = [red], arrows = medium, scene = [t, e2(t)])
> i11 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..1, i1 = 0..0.05, r1 = 0..1, s2 = 0..1, e2 = 0..1, i2 = 0..1, r2 = 0..1, TR = 0
  ..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linecolor = [red], arrows = medium, scene = [t, i1(t)])
> i21 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..1, i1 = 0..1, r1 = 0..1, s2 = 0..1, e2 = 0..1, i2 = 0..0.05, r2 = 0..1, TR = 0
  ..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linecolor = [red], arrows = medium, scene = [t, i2(t)])
> r11 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..1, i1 = 0..1, r1 = 0..0.05, s2 = 0..1, e2 = 0..1, i2 = 0..1, r2 = 0..1, TR = 0
  ..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linecolor = [red], arrows = medium, scene = [t, r1(t)])
> r21 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..1, i1 = 0..1, r1 = 0..1, s2 = 0..1, e2 = 0..1, i2 = 0..1, r2 = 0..0.1, TR = 0
  ..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linecolor = [red], arrows = medium, scene = [t, r2(t)])
> TR1 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..1, i1 = 0..1, r1 = 0..1, s2 = 0..1, e2 = 0..1, i2 = 0..1, r2 = 0..1, TR = 0
  ..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linecolor = [red], arrows = medium, scene = [t, TR(t)])
>
> display([s11], labels = [t(waktu), Individu rentan Tb tanpa Dm(S1)], labeldirections = [horizontal, vertical]):
> display([s21], labels = [t(waktu), Individu rentan Tb kotifeksi Dm(S2)], labeldirections = [horizontal, vertical]):
>
> display([e11], labels = [t(waktu), Individu laten Tb tanpa Dm(R1)], labeldirections = [horizontal, vertical]):
> display([e21], labels = [t(waktu), Individu laten Tb tanpa Dm(R2)], labeldirections = [horizontal, vertical]):
> display([i11], labels = [t(waktu), Individu laten Tb tanpa Dm(I1)], labeldirections = [horizontal, vertical]):
> display([i21], labels = [t(waktu), Individu laten Tb tanpa Dm(I2)], labeldirections = [horizontal, vertical]):
>
> display([r11], labels = [t(waktu), Individu sembuh Tb kotifeksi Dm(R1)], labeldirections = [horizontal, vertical]):
> display([r21], labels = [t(waktu), Individu sembuh Tb kotifeksi Dm(R2)], labeldirections = [horizontal, vertical]):
>
> display([TR1], labels = [t(waktu), Individu dengan treatment DOTS], labeldirections = [horizontal, vertical]):
>

```

6. Perubahan parameter kontak infeksi TB aktif yang terkena DM dengan $w_2=2$, $w_2=6$, $w_2=10$.

```

> restart:
> with(intalg): with(plots): with(DEtools):
>
> beta := 1.2: c1 := 0.05: c2 := 0.7: theta := 1.5: tau := 1.01: alpha := 0.3: p1 := 0.3: p2 := 0.6: mu := 1.5: d1 := 0.09: d2 := 0.10: g := 0.15: psi1 := 0.7: psi2 := 0.9: w1 := 1:
  w2 := 2: delta1 := 0.91: delta2 := 1: n1 := 0.25: n2 := 0.55: e := 0.8806:
> x1 := (1 - p1) * (mu / (alpha + mu)): x2 := p1 * (mu / (alpha + mu)): x3 := theta * (1 - p2) * (alpha / (alpha + mu)): x4 := theta * p2 * (alpha / (alpha + mu)): y1 := (alpha + mu + c1 + psi1): y2 := (mu + d1 - tau * alpha - w1 - n1):
  y3 := (mu + theta * c2 + psi2): y4 := (mu + d2 - w2 - n2):
> R0 := (alpha * c1 * tau * x1 * y3 + alpha * c2 * theta * x1 * y2 + alpha * tau * x2 * y1 * y3 + c2 * theta * x3 * y1 * y2 + x4 * y1 * y2 * y3 + c1 * x1 * y3 * y4 + x2 * y1 * y3 * y4) /
  (y1 * y2 * y3 * y4)
>
> lambda22 := beta * (i1(t) + e * i2(t)):
> T1 := d/dt s1(t) = mu - (alpha + mu + lambda22) * s1(t):
> T2 := d/dt e1(t) = (1 - p1) * lambda22 * s1(t) - (alpha + mu + c1 + psi1) * e1(t):
> T3 := d/dt i1(t) = p1 * lambda22 * s1(t) + c1 * e1(t) + (1 - g) * delta1 * TR(t) - (mu + d1 + tau * alpha + w1 + n1) * i1(t):
> T4 := d/dt r1(t) = n1 * i1(t) + g * c1 * TR(t) - (alpha + mu) * r1(t):
> T5 := d/dt s2(t) = alpha * s1(t) - (mu + theta * lambda22) * s2(t):
> T6 := d/dt e2(t) = alpha * e1(t) + theta * (1 - p2) * lambda22 * s2(t) - (mu + theta * c2 + psi2) * e2(t):
> T7 := d/dt i2(t) = tau * alpha * i1(t) + theta * p2 * lambda22 * s2(t) + theta * c2 * e2(t) + theta * (1 - g) * delta2 * TR(t) - (mu + d2 + w2 + n2) * i2(t):
> T8 := d/dt r2(t) = alpha * r1(t) + n2 * i2(t) + g * delta2 * TR(t) - mu * r2(t):

```



```

> β := 1.2; σ1 := 0.05; σ2 := 0.7; θ := 1; τ := 1.01; α := 0.3; p1 := 0.3; p2 := 0.6; μ := 1.5; d1 := 0.09; d2 := 0.10; q := 0.15; ψ1 := 0.7; ψ2 := 0.9; w1 := 0.05;
w2 := 10; δ1 := 0.91; δ2 := 1; n1 := 0.25; n2 := 0.55; e := 0.8806;
> x1 := (1 - p1) * (μ / (α + μ)); x2 := p1 * (μ / (α + μ)); x3 := θ * (1 - p2) * (α / (α + μ)); x4 := θ * p2 * (α / (α + μ)); y1 := (α + μ + σ1 + ψ1); y2 := (μ + d1 - τ * α - w1 - n1);
y3 := (μ + θ * σ2 + ψ2); y4 := (μ + d2 - w2 - n2);
> R0 := (β * (α * σ1 * τ * x1 * y3 + α * σ2 * θ * x3 * y1 * y2 + x4 * y1 * y2 * y3 + σ1 * x1 * y3 * y4 + x2 * y1 * y3 * y4)) / (y1 * y2 * y3 * y4);
> λ22 := β * (i1(t) + e * i2(t));
> T1 := d/dt s1(t) = μ - (α + μ + λ22) * s1(t);
> T2 := d/dt e1(t) = (1 - p1) * λ22 * s1(t) - (α + μ + σ1 + ψ1) * e1(t);
> T3 := d/dt i1(t) = p1 * λ22 * s1(t) + σ1 * e1(t) + (1 - q) * δ1 * TR(t) - (μ + d1 + τ * α + w1 + n1) * i1(t);
> T4 := d/dt r1(t) = n1 * i1(t) + q * σ1 * TR(t) - (α + μ) * r1(t);
> T5 := d/dt s2(t) = α * s1(t) - (μ + θ * λ22) * s2(t);
> T6 := d/dt e2(t) = α * e1(t) + θ * (1 - p2) * λ22 * s2(t) - (μ + θ * σ2 + ψ2) * e2(t);
> T7 := d/dt i2(t) = τ * α * i1(t) + θ * p2 * λ22 * s2(t) + θ * σ2 * e2(t) + θ * (1 - q) * δ2 * TR(t) - (μ + d2 + w2 + n2) * i2(t);
> T8 := d/dt r2(t) = α * r1(t) + n2 * i2(t) + q * δ2 * TR(t) - μ * r2(t);
> T9 := d/dt TR(t) = w1 * i1(t) + w2 * i2(t) + ψ1 * e1(t) + ψ2 * e2(t) - μ * TR(t);
> T9 := d/dt TR(t) = w1 * i1(t) + w2 * i2(t) + ψ1 * e1(t) + ψ2 * e2(t) - μ * TR(t);
>
> s11 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..10, i1 = 0..10, r1 = 0..10, s2 = 0..10, e2 = 0..10, i2 = 0..10, r2 = 0..10, TR = 0..10, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linecolor = [red], arrows = medium, scene = [t, s1(t)]);
> s21 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..10, i1 = 0..10, r1 = 0..10, s2 = 0..0.2, e2 = 0..1, i2 = 0..1, r2 = 0..1, TR = 0..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linecolor = [red], arrows = medium, scene = [t, s2(t)]);
> e11 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..10, i1 = 0..10, r1 = 0..10, s2 = 0..1, e2 = 0..1, i2 = 0..1, r2 = 0..1, TR = 0..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linecolor = [red], arrows = medium, scene = [t, e1(t)]);
> e21 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..10, i1 = 0..10, r1 = 0..10, s2 = 0..0.2, e2 = 0..0.07, i2 = 0..1, r2 = 0..1, TR = 0..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linecolor = [red], arrows = medium, scene = [t, e2(t)]);
> i11 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..10, i1 = 0..10, r1 = 0..10, s2 = 0..1, e2 = 0..1, i2 = 0..1, r2 = 0..1, TR = 0..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linecolor = [red], arrows = medium, scene = [t, i1(t)]);
> i21 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..10, i1 = 0..10, r1 = 0..10, s2 = 0..0.1, e2 = 0..0.05, r2 = 0..1, TR = 0..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linecolor = [red], arrows = medium, scene = [t, i2(t)]);
> r11 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..10, i1 = 0..10, r1 = 0..10, s2 = 0..1, e2 = 0..1, i2 = 0..1, r2 = 0..1, TR = 0..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linecolor = [red], arrows = medium, scene = [t, r1(t)]);
> r21 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..10, i1 = 0..10, r1 = 0..10, s2 = 0..1, e2 = 0..1, i2 = 0..1, r2 = 0..0.1, TR = 0..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linecolor = [red], arrows = medium, scene = [t, r2(t)]);
> TR1 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8, T9], [s1(t), e1(t), i1(t), r1(t), s2(t), e2(t), i2(t), r2(t), TR(t)], t = 0..10, s1 = 0..1, e1 = 0..10, i1 = 0..10, r1 = 0..10, s2 = 0..1, e2 = 0..1, i2 = 0..1, r2 = 0..1, TR = 0..0.2, TR = 0..1, [[s1(0) = 0.1158, e1(0) = 0.0589, i1(0) = 0.0135, r1(0) = 0.03, s2(0) = 0.0766, e2(0) = 0.0554, i2(0) = 0.02, r2(0) = 0.06, TR(0) = 0.05]], linecolor = [red], arrows = medium, scene = [t, TR(t)]);
>
> display([s11], labels = [t(waktu), Individu rentan Tb tanpa Dm(S1)], labeldirections = [horizontal, vertical]);
> display([s21], labels = [t(waktu), Individu rentan Tb kotifeksi Dm(S2)], labeldirections = [horizontal, vertical]);
> display([e11], labels = [t(waktu), Individu laten Tb tanpa Dm(E1)], labeldirections = [horizontal, vertical]);
> display([e21], labels = [t(waktu), Individu laten Tb tanpa Dm(E2)], labeldirections = [horizontal, vertical]);
> display([i11], labels = [t(waktu), Individu laten Tb tanpa Dm(I1)], labeldirections = [horizontal, vertical]);
> display([i21], labels = [t(waktu), Individu laten Tb tanpa Dm(I2)], labeldirections = [horizontal, vertical]);
> display([r11], labels = [t(waktu), Individu sembuh Tb kotifeksi Dm(R1)], labeldirections = [horizontal, vertical]);
> display([r21], labels = [t(waktu), Individu sembuh Tb kotifeksi Dm(R2)], labeldirections = [horizontal, vertical]);
> display([TR1], labels = [t(waktu), Individu dengan treatment DOTS], labeldirections = [horizontal, vertical]);

```

7. Sintaks Grafik perubahan nilai R0 terhadap parameter β

```

> restart;
> with(plots): with(implicitplot): with(DEtools);
> β := 0.0225; σ1 := 0.045; θ := 2; τ := 1.01; α := 0.009; p1 := 0.03; p2 := 0.06; μ := 0.018; d1 := 0.275; d2 := 0.3437; q := 0.7; ψ1 := 0.013; ψ2 := 0.026; w1 := 1; w2 := 2;
δ1 := 0.0986; δ2 := 0.1; n1 := 0.25; n2 := 0.17; e := 1.1;
> λ := β * (I1 + e * I2);
> x1 := (1 - p1) * (μ / (α + μ)); x2 := p1 * (μ / (α + μ)); x3 := θ * (1 - p2) * (α / (α + μ)); x4 := θ * p2 * (α / (α + μ)); y1 := (α + μ + σ1 + ψ1); y2 := (μ + d1 + τ * α + w1 + n1); y3 := (μ + θ * σ2
+ ψ2); y4 := (μ + d2 + w2 + n2);
> R0 := (β * (α * σ1 * τ * x1 * y3 + α * σ2 * θ * x3 * y1 * y2 + (x4 * y1 * y2 * y3) + σ1 * x1 * y3 * y4 + x2 * y1 * y3 * y4)) / (y1 * y2 * y3 * y4);
R0 = 0.3702158419 β
>
> plot(R0, β = 0..4);

```

8. Sintaks Grafik perubahan nilai R0 terhadap parameter w_1

```

> restart :
> with(linalg) : with(plots, implicitplot) : with(DEtools) :
> beta := 3 : sigma1 := 0.0225 : sigma2 := 0.045 : theta := 2 : tau := 1.01 : alpha := 0.009 : p1 := 0.03 : p2 := 0.06 : mu := 0.018 : d1 := 0.275 : d2 := 0.3437 : q := 0.7 : psi1 := 0.013 : psi2 :=
0.026 : w1 := w1 : w2 := 2 : delta1 := 0.0986 : delta2 := 0.1 : n1 := 0.25 : n2 := 0.17 : e := 1.1 :
> lambda := beta * (I1 + e * I2) :
> x1 := (1 - p1) * (mu / (alpha + mu)) : x2 := p1 * (mu / (alpha + mu)) : x3 := theta * (1 - p2) * (alpha / (alpha + mu)) : x4 := theta * p2 * (alpha / (alpha + mu)) : y1 := (alpha + mu + sigma1 + psi1) : y2 := (mu + d1 + tau * alpha + w1 + n1) :
y3 := (mu + theta * sigma2 + psi2) : y4 := (mu + d2 + w2 + n2) :
> R0 := (beta * (sigma1 * tau * x1 * y3 + alpha * sigma2 * theta * x1 * y2 + alpha * tau * x2 * y1 * y3 + (sigma2 * theta * x3 * y1 * y2) + (x4 * y1 * y2 * y3) + sigma1 * x1 * y3 * y4 + x2 * y1 * y3 * y4)
y1 * y2 * y3 * y4
R0 := 141.4894953 (0.007799612730 + 0.004383800000 w1)
w1 + 0.55209
>
> plot(R0, w1 = 1..5) :

```

9. Sintaks Grafik perubahan nilai R0 terhadap parameter w_2

```

> restart :
> with(linalg) : with(plots, implicitplot) : with(DEtools) :
> beta := 3 : sigma1 := 0.0225 : sigma2 := 0.045 : theta := 2 : tau := 1.01 : alpha := 0.009 : p1 := 0.03 : p2 := 0.06 : mu := 0.018 : d1 := 0.275 : d2 := 0.3437 : q := 0.7 : psi1 := 0.013 : psi2 :=
0.026 : w1 := 1 : w2 := w2 : delta1 := 0.0986 : delta2 := 0.1 : n1 := 0.25 : n2 := 0.17 : e := 1.1 :
> lambda := beta * (I1 + e * I2) :
> x1 := (1 - p1) * (mu / (alpha + mu)) : x2 := p1 * (mu / (alpha + mu)) : x3 := theta * (1 - p2) * (alpha / (alpha + mu)) : x4 := theta * p2 * (alpha / (alpha + mu)) : y1 := (alpha + mu + sigma1 + psi1) : y2 := (mu + d1 + tau * alpha + w1 + n1) :
y3 := (mu + theta * sigma2 + psi2) : y4 := (mu + d2 + w2 + n2) :
> R0 := (beta * (sigma1 * tau * x1 * y3 + alpha * sigma2 * theta * x1 * y2 + alpha * tau * x2 * y1 * y3 + (sigma2 * theta * x3 * y1 * y2) + (x4 * y1 * y2 * y3) + sigma1 * x1 * y3 * y4 + x2 * y1 * y3 * y4)
y1 * y2 * y3 * y4
R0 := 230.7913557 (0.007949012730 + 0.002117200000 w2)
0.5317 + w2
>
> plot(R0, w2 = 2..10) :

```