Soil Phosphorus Data Requirements for DSSAT

DSSAT Version 4.8.5
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The Cropping System Model of DSSAT Version 4.8 soil phosphorus model maintains four inorganic P pools (solution, labile, active and stable) and several organic P pools (microbial and stable humic material and metabolic and structural fresh organic matter). Accurate estimations of the correct initial proportions of P in each pool are critical to modeling the P transformations and predicting the soluble P quantities that are available for uptake by plants. This document summarizes the variables needed to correctly initialize the organic and inorganic soil phosphorus parameters.

As a minimum, the soil phosphorus model requires that the user supply a value of measured extractable soil phosphorus for each soil layer and the method of extraction. The soil pH and total organic carbon (OC) are also very important for accurate initialization, although the model can be run if these data are missing. Missing OC data are estimated based on soil texture and missing pH data are assigned a value of 7.0. For adequate modeling of soil phosphorus processes, the user should supply measured values of both OC and pH, as the default values are likely to result in inaccurate predictions of soil P quantities. All soil P parameters can be estimated from extractable P, OC and pH, but the reliability of the estimates improves if additional measured soil data are available.

Computations of the relative amounts of the inorganic P components and of the transformation rates between components are based on general soil classification categories assigned to each soil layer, and on chemical composition of each layer. The criteria used for this classification are listed in Table 1 for the four general soil classes: andisols, calcareous, slightly weathered, and highly weathered soils. Extractable phosphorus can be measured directly by one of several methods. Equations are used to compute labile and other inorganic P components from the measured extractable phosphorus, and these equations vary with the extraction method and the soil class. The extraction methods used for each soil class are listed in Table 2.

Table 1. Criteria used for assigning soil classifications

Soil Class	Criteria
Andisol	Soil description or taxonomy includes the terms 'ANDOSOL' or 'ANDISOL' or 'VOLCAN' or 'ANDEPT'.
Calcareous	High calcium carbonate content. CaCO3(L) > 0.15%
Slightly weathered	High ratio of cation exchange capacity to clay content. CEC(L)/(CLAY(L)/100.) > 16.
Highly weathered	Low ratio of cation exchange capacity to clay content. CEC(L)/(CLAY(L)/100.) <= 16.
Other or unspecified	Any other soils, or soils which cannot be classified based on available data.

Regression equations, determined from measurements of phosphorus in many different soils (Sharpley, et al., 1984, 1989, Singh, 1985), are used to estimate the labile P content from soil type and measured extractable P. In some cases, additional soil chemical parameters are used in the calculations, if provided. Table 3 lists the data that can be used to determine labile P content and other soil P components for each soil class. Note that some data can be entered in both the soil file and the soil analysis section of the experiment file. The soil profile contains data which are typical of a particular soil type, whereas, the soil analysis section of the experiment file contains data which were analyzed for a specific field, usually at the initiation of an experiment. Data provided in the soil analysis section of the experiment file override the more generic soil file data if both are provided.

Table 2. Phosphorus extraction methods with corresponding method code (input in File X) used in DSSAT v4.8 for soil categories.

Phosphorus extraction method	Extraction method code (SMPX)	Soil class				
		Calcareous	Slightly weathered	Highly weathered	Andisol	Other
Olsen	SA001	X	X	X	X	X
Bray No. 1	SA002	X	X	X	X	X
Mehlich I (double acid, 1:5)	SA004		X	X	X	
Anion exchange resin	SA005	X	X	X	X	X
Truog	SA006		X	X	X	X
Mehlich I (double acid, 1:10)	SA007			X		
Colwell	SA008			X		
Water	SA009	X				
IFDC Pi strip	SA010	X	X	X	X	X
Morgan's solution	SA014		X			

The phosphorus availability index is computed as a measure of the activity level of the P in the soil. This factor is estimated based on calcium carbonate for calcareous soils; base saturation, labile P and pH for slightly weathered soils; clay content for highly weathered soils; and on labile P for all other cases.

Rates of transformation between the various inorganic P pools are computed from labile P and P availability index. The transformation rates in turn determine the equilibrium ratios of the inorganic P components.

Initial quantities of P in the organic matter pools are estimated based on pH, organic C and soil class for each soil layer; or organic phosphorus can be input directly for each soil layer in the soil profile data.

Figure 1 presents a listing of a soil profile used with a phosphorus experiment in Tanzania with required, recommended and optional soil P data highlighted.

The INFO.OUT file, generated during a DSSAT v4.8 simulation, contains details about how inorganic soil P components were initialized for each soil layer and the soil parameters that were used in the calculations. Users are encouraged to open this file, which is found in the data output directory, to review computation methods, input data used and the computed P components. Figure 2 lists a sample of output information from the INFO.OUT file regarding estimation of initial soil P data using the soil profile data listed in Figure 1.

Table 3. Soil parameters used to initialize organic and inorganic P variables. Data requirements vary with soil class.

Soil data used to initialize phosphorus pools	Importance	Soil file header	Soil Analysis header	Soil class which uses this data			
				Calcar-eous	Slightly weathered	Highly weathered	Andisol or other
Extractable phosphorus (mg kg^{-1})	Required	SLPX	SAPX	X	X	X	X
Phosphorus extraction method (see Table 2)	Required	SMPX	SMPX	X	X	X	X
pH	Recommended (default 7.0)	SLHW	SAPHW	X	X	X	X
Total organic carbon , OC (g/100g)	Recommended	SLOC	SAOC	X	X	X	X
Total soil phosphorus (mg kg^{-1})	Optional	SLPT	--	X	X	X	X
Organic P (mg kg^{-1})	Optional	SLPO	--	X	X	X	X

Calcium carbonate CaCO3 (g kg^{-1})	Recommended for calcareous soils	CACO3	--	X			
Exchangeable potassium (cmol kg^{-1})	Recommended for slightly weathered soils	SLKE	SAKE		X		
Method of potassium extraction	Optional	SMKE	SMKE		X		
Base saturation (cmol kg^{-1})	Optional	SLBS	--		X		
Cation exchange capacity CEC (cmol kg^{-1})	Recommended	SCEC	--		X	X	
Clay content (%)	Recommended	SLCL	--		X	X	

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*SUMO930002  MOROGORO, TZ SALO 100   OXISOL ISOHYPERTHEMIC, ARIDIC  TROPUSTIC

@SITE         COUNTRY           LAT     LOG  SCS FAMILY
 MOROGORO     TANZANIA         -6.5    37.3 REDDISH BROWN SAND LOAM

@ SCOM  SALB  SLUI  SLDR  SLRO  SLNF  SLPF  SMHB  SMPX  SMKE  SRGP
 2.5YR  0.12   6.0  0.50  84.0  1.00  0.80 IB001 SA005 IB001 IB003

@  SLB  SLMH  SLLL  SDUL  SSAT  SRGF  SSKS  SBDM  SLOC  SLCL  SLSI  SLCF  SLNI  SLHW  SLHB  SCEC  SADC
    10    Ap 0.091 0.227 0.382 1.000 16.56  1.55  1.13  60.0  20.0  20.0  0.06  4.56   -99  8.97   -99
    20    Ap 0.066 0.202 0.382 0.841 16.56  1.55  1.13  65.0  30.0  15.0  0.06  4.50   -99  8.89   -99
    30     E 0.104 0.240 0.399 0.499 16.16  1.50  0.76  65.0  15.0  30.0  0.05  5.38   -99  5.65   -99
    40    AB 0.125 0.261 0.365 0.338 16.56  1.60  0.76  53.0  13.0  24.0  0.06  5.50   -99  5.31   -99
    50    B1 0.088 0.224 0.382 0.166  6.98  1.55  0.70  65.0  13.0  22.0  0.05  5.69   -99  5.44   -99
    60    B2 0.165 0.301 0.347 0.134  5.98  1.65  0.70  55.0  10.0  35.0  0.04  4.59   -99  3.77   -99
    70    B2 0.053 0.189 0.417 0.019  5.98  1.45  0.40  68.0  15.0  17.0  0.04  4.23   -99  3.31   -99
    80    B2 0.159 0.295 0.417 0.016 16.55  1.45  0.33  40.0  24.0  36.0  0.05  5.14   -99  2.03   -99
    90    B3 0.154 0.290 0.434 0.012  5.99  1.40  0.33  35.0  30.0  35.0  0.05  4.46   -99  1.91   -99
   100    B3 0.089 0.225 0.472 0.003  5.99  1.29  0.30  38.0  22.0  20.0  0.03  4.61   -99  1.94   -99

@  SLB  SLPX  SLPT  SLPO CACO3  SLAL  SLFE  SLMN  SLBS  SLPA  SLPB  SLKE  SLMG  SLNA  SLSU  SLEC  SLCA
    10  5.42   270 120.0  1.77   1.5  3.20   -99   -99   -99   -99   1.6  5.60  0.19   -99   -99   -99
    20  5.03   270 120.0  1.59   1.5  3.20   -99   -99   -99   -99   1.6  5.70  0.19   -99   -99   -99
    30  4.33   242 120.0  1.45   1.4  3.00   -99   -99   -99   -99   1.4  2.80  0.22   -99   -99   -99
    40  4.01   170  80.0  1.31   1.3  2.87   -99   -99   -99   -99   1.4  2.60  0.22   -99   -99   -99
    50  3.31   170  80.0  1.24   1.3  2.86   -99   -99   -99   -99   1.4  2.80  0.22   -99   -99   -99
    60  3.14   170  80.0  1.07   1.3  2.20   -99   -99   -99   -99   0.4  2.30  0.22   -99   -99   -99
    70  2.89   170  80.0  0.61   1.3  2.20   -99   -99   -99   -99   0.4  2.30  0.16   -99   -99   -99
    80  3.33    75  50.0  0.33   1.3  1.29   -99   -99   -99   -99   0.4  1.30  0.16   -99   -99   -99
    90  2.42    75  50.0  0.34   1.3  1.87   -99   -99   -99   -99   0.4  1.20  0.16   -99   -99   -99
   100  2.41    75  50.0  0.34   1.2  1.10   -99   -99   -99   -99   0.4  1.20  0.16   -99   -99   -99
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Figure 1. Listing of sample soil profile with phosphorus input data used with a phosphorus experiment in Tanzania with highlighted fields for:

- ***required data (red),***
- ***recommended data (green) and***
- ***optional data (blue)***

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SOILDYN  YEAR DOY = 1994  63
 Soil layer classifications (used for soil P model)
 Layer Depth Soil_Layer_Type   Backup_Data
   1      5  CALCAREOUS        CaCO3:  0.18%
   2     15  CALCAREOUS        CaCO3:  0.17%
   3     30  HIGHLYWEATHERED   CaCO3:  0.15%; CEC:   6.7 cmol/kg; CLAY:  65.0%
   4     45  HIGHLYWEATHERED   CaCO3:  0.13%; CEC:   5.3 cmol/kg; CLAY:  57.0%
   5     60  HIGHLYWEATHERED   CaCO3:  0.11%; CEC:   4.3 cmol/kg; CLAY:  58.3%
   6     80  HIGHLYWEATHERED   CaCO3:  0.05%; CEC:   2.7 cmol/kg; CLAY:  54.0%
   7    100  HIGHLYWEATHERED   CaCO3:  0.03%; CEC:   1.9 cmol/kg; CLAY:  36.5%

SOMINI  YEAR DOY = 1994  63
Soil layer  1
Organic P read from soil file: 120.00 ppm
C:P ratio below acceptable range.
Revised Organic P: 113.26

SPINIT  YEAR DOY = 1994  63
Soil layer:  1
Soil type: CALCAREOUS
P extraction method: SA005
Measured P =    5.40 ppm
Labile P   =    5.40 ppm
Active P   =   27.05 ppm
Stable P   =  108.19 ppm
P Avail Index   =    0.60
Rate PLab->PAct = 0.02455/d
Rate PAct->PLab = 0.00490/d
Rate PAct->PSta = 0.00030/d
Rate PSta->PAct = 0.00010/d
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Figure 2. Listing of selected output from INFO.OUT file showing P initialization based on soil profile inputs presented in Figure 1.

References

Sharpley A.N., Jones C.A., Gray C. and Cole C.V. 1984. A simplified soil and plant phosphorus model II. Prediction of labile, organic, and sorbed phosphorus. Soil Sci. Soc. Am. J. 48:805-809.

Sharpley A.N., Singh U., Uehara G. and Kimble J. 1989. Modeling soil and plant phosphorus dynamics in calcareous and highly weathered soils. Soil Sci. Soc. Am. J. 53:153-158.

Singh, U. 1985. A crop growth model for predicting corn (Zea mays L.) performance in the tropics. Ph.D. thesis. Univ. of Hawaii, Honolulu.