Equations and formulas that have been suggested

by

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The general formula for economic evaluation of crop sequence and relay intercropping systems from the perspective on the crop intensification:

$$NR_{/d}.Seq._{"n"}(\text{Sequence}_{"n"}) = [(\sum_{L=1}^{m}(\sum_{k=1}^{mL}(Y_{nlk}\,Pr_{nlk}) - Co_{nL})) + (\sum_{i=1}^{n}(\sum_{j=1}^{ni} Y_{nij}\,Pr_{nij}) - \sum_{i=1}^{n} Co_{ni})][D_n]^{-1}$$

(EL-Hawary,**2014**)……….**(19)**

Where :$NR_{/d}.Seq._{"n"}$: Net return per day of sequence $_{"n"}$ and expressed as (Sequence $_{"n"}$) . D_n :the duration by days of the sequence .

The computation of economic yield advantage ratio (EYAR)of the succession by using the general formula and expressed as $EYAR_5$ is as follows :

$$EYAR_5 = [NR_{/d}.Seq._{"a"}]\,[NR_{/d}.Seq._{"b"}]^{-1}$$

or $$EYAR_5 = [\text{Sequence}_{“a”}][\text{Sequence}_{“b”}]^{-1}$$

Where :

$$\text{Sequence}_{"a"} = [(\sum_{L=1}^{m}(\sum_{k=1}^{mL}(Y_{alk}\,Pr_{alk}) - Co_{al})) + (\sum_{i=1}^{n}(\sum_{j=1}^{ni} Y_{aij}\,Pr_{aij}) - \sum_{i=1}^{n} Co_{ai})][D_a]^{-1}$$

$$\text{Sequence}_{"b"} = [(\sum_{L=1}^{m}(\sum_{k=1}^{mL}(Y_{blk}\,Pr_{blk}) - Co_{bl})) + (\sum_{i=1}^{n}(\sum_{j=1}^{ni} Y_{bij}\,Pr_{bij}) - \sum_{i=1}^{n} Co_{bi})][D_b]^{-1}$$

Where :

m : number of monoculture crops pertaining to crop sequence .*mL* : the total number of main and by-products together of the monoculture crop available for every *L*(where *L* is monoculture crop) .

n: number of simultaneous or relay intercropping crops pertaining to crop sequence . *ni* : the total number of main and by-products together of the intensive crop available for every *i* (where *i* is intensive crop) .

Y_{alk} , Pr_{alk} and Co_{alk} :Yield, price and production cost (main and by-products) of each crop of monoculture crops of sequence "*a*" , respectively.

Y_{aij} , Pr_{aij} and Co_{aij} :Yield, price and production cost (main and by-products) of each crop of crop sequence "*a*" , respectively.

Y_{blk} , Pr_{blk} and Co_{blk} :Yield, price and production cost (main and by-products) of each crop of monoculture crops of sequence "*b*" , respectively.

Y_{bij} , Pr_{bij} and Co_{bij} :Yield, price and production cost (main and by-products) of each crop of intensive sequence "*b*" , respectively.

$\sum_{i=1}^{n} Co_{ni}$ = Total costs of intensive sequence .

D_a and D_b are the durations by days of sequences "*a*" and "*b*". respectively

$EYAR_5$ = [NR /day of sequence "*a*'][NR /day of sequence "*b*']$^{-1}$

$EYAR_5$ value as percentage =($EYAR_5$ value -1) x 100 = ± **%**

So, $EYAR_5$ value given was relative to the net return per day of sequence that used as compared (sequence "*b*") .

The computation of the yield advantage (or disadvantage) net return of sequence "*a*" is as follows :

Yield advantage (or disadvantage) net return = ± LE/F.

=(NR of the evaluated sequence "*a*") – (NR of the compared sequence "*b*") **.**

= (Gross income –total costs of evaluated seq.) - (Gross income –total costs of compared seq.)

Economic evaluation of the simultaneous intercropping system from the perspective of crop intensification:

Modified Economic Land Equivalent Ratio " MELER ":

MELER = A/O + B/O +C/O (El-Hawary , **2011**) …………………**(18)**

$$A = \left(\sum_{L=1}^{m^-} Y_{aL}\, Pr_{aL} \right) \quad , \quad C = (C_o - C_1)$$

$$B = \left(\sum_{K=1}^{n} \left(\sum_{L=1}^{n^-} Y_{bkL}\, Pr_{bkL} \right) \right) \quad , \quad O = \left(\sum_{L=1}^{m} Y_{oL}\, Pr_{oL} \right)$$

Where :

A= First or major crop . B= Secondary crop (s) . C= Cost difference.

O= monoculture crop .

n and m- , *n-* and *m* : Number of secondary crops and number of main and by products together of first or major crop (which n^- varies according to each crop (where $n^-=nk$), secondary crop and monoculture crop (that substituted by intercropping crops) , respectively .

Y_{aL} , Y_{bkL} and Y_{oL} : Yield /F. of main and by products of first or major crop , secondary crop (s) and monoculture crop (that substituted by intercropping crops) , respectively .

Pr_{aL} , Pr_{bkL} and Pr*oL* : Price of production unit of main and by products of first or major crop , secondary crop (s) and monoculture crop (that substituted by intercropping crops) , respectively . Co and C1 : Total costs of monoculture crop (or that substituted by intercropping crops) and the intercropping crops , respectively .

The computation of the intercropping advantage net return is as follows:

=Gross income of the compared crop x (MELER value (of the treatment) -1)

The computation of the total net return is as follows:

= (Gross income of the compared crop – cost) + (Net return of the intercropping advantage of the treatment) .

Net return of relay intercropping system :

$$NR_{relay} = \ =\left(\sum_{i=1}^{n} \left(\sum_{j=1}^{n^{-}} Y_{aij}\, Pr_{aij}\right) - \sum_{i=1}^{n} Co_{ai}\right) .$$

(El-Hawary , **2011**) …………….**(17)**

Where :

n : number of crops pertaining to crop sequence (a) . n^{-} : number of main and by products together of the crop . which n^{-} varies according to each crop (where $n^{-}=ni$).

Y_{aij} , Pr_{aij} and Co_{aij} :Yield, price and production cost (main and by products)of each crop pertaining to crop sequence (a) , respectively.

Net return of the traditional crop sequence :

$$NR_{seq} = \left(\sum_{L=1}^{m} \left(\sum_{K=1}^{m^{-}} \left(Y_{bLK}\, Pr_{bLK}\right) - Co_{bL}\right)\right) .$$

(El-Hawary , **2011**) ………………**(16)**

Where :

m: number of crops pertaining to crop sequence (b) . m^{-} : number of main and by products together of the crop . which m^{-} varies according to each crop(where $m^{-}=mL$) .

Y_{bLK} ,Pr_{bLK} and Co_{bLK} : Yield, price and production cost (main and by products) of each crop pertaining to crop sequence (b) , respectively.

Economic evaluation of water irrigation amounts of sequences :

$$NR_{relay} / (M_{relay}) = \left(\sum_{i=1}^{n} \left(\sum_{j=1}^{n^-} Y_{aij} Pr_{aij} \right) - \sum_{i=1}^{n} Co_{ai} \right) (M_{relay})^{-1}$$

(El-Hawary , **2011**) ……………**(15)**

$$NR_{seq} / (M_{sequ.}) = \left(\sum_{L=1}^{m} \left(\sum_{K=1}^{m^-} (Y_{bLK} Pr_{bLK}) - Co_{bL} \right) \right) (M_{sequ.})^{-1}$$

(El-Hawary , **2011**) ………..…**(14)**

Where : M_{relay} and M_{sequ}. are water requirements per feddan of relay intercropping and sequence systems ,respectively .

Evaluation of relay intercropping in comparison with a sequence from the perspective of crop intensification:

Economical Yield Advantage Ratio (relay/ sequ.) (EYAR1) :

$$EYAR_1 = \left[\left(\sum_{i=1}^{n} \left(\sum_{j=1}^{n^-} Y_{aij} Pr_{aij} \right) - \sum_{i=1}^{n} Co_{ai} \right) D_b \right] \left[\left(\sum_{L=1}^{m} \left(\sum_{K=1}^{m^-} (Y_{bLK} Pr_{bLK}) - Co_{bL} \right) \right) D_a \right]^{-1}$$

(El-Hawary , **2009**) **…………... (13)**

Economical Yield Advantage Ratio as percentage = ((EYAR1) -1)x 100= + %

Where :

Formula numerator should be occupied by crop sequence (a) (relay intercropping crops) .

Formula denominator should be occupied by crop sequence (b).

n : number of crops pertaining to crop sequence (a) . *n*- :number of main and by- products together of the crop . Which n^- varies according to each crop ((where $n^-=ni$).

m: number of crops pertaining to crop sequence (b) . *m*- : number of main and by-products together of the crop . Which m^- varies according to each crop (where $m^-=mL$)..

Y_{aij} , Pr_{aij} and Co_{aij} :Yield, price and production cost (main and by-products)of each crop pertaining to crop sequence (a) , respectively.

Y_{bLK} ,Pr_{bLK} and Co_{bLK} : Yield, price and production cost (main and by- products) of each crop pertaining to crop sequence (b) , respectively.

D_a and D_b : Crop sequence (a) and crop sequence (b) durations by days, respectively.

The computation of the yield advantage (or disadvantage) net return of sequence "*a*" is as follows :

Yield advantage (or disadvantage) net return = ± LE/F.

=(NR of the evaluated sequence "*a*") – (NR of the compared sequence "*b*") **.**

= (Gross income –total costs of evaluated seq.) - (Gross income –total costs of compared seq.)

<u>Evaluation of Sequence in comparison with another sequence</u> <u>from the perspective of crop intensification:</u>

Economical Yield Advantage Ratio (seq / sequ.) (EYAR2) :

$$EYAR_2 = [(\sum_{i=1}^{n} (\sum_{j=1}^{n^-} (Y_{aij} Pr_{aij}) - Co_{ai})) D_b] [(\sum_{L=1}^{m} (\sum_{K=1}^{m^-} (Y_{bLK} Pr_{bLK}) - Co_{bL})) D_a]^{-1}$$

(El-Hawary , **2009**) **………………. (1**2)

Economical Yield Advantage Ratio(sequ/ sequ.) as percentage= ((EYAR2) -1)x 100= + %

Formula numerator should be occupied by crop sequence (a).

Formula denominator should be occupied by crop sequence (b).

n : number of crops pertaining to crop sequence (a) . n- : number of main and by products together the crop . Which n^- varies according to each crop (where $n^-=ni$).

m: number of crops pertaining to crop sequence (b) . m- : number of main and by products together the crop . Which m^- varies according to each crop (where $m^-=mL$)..

Y_{aij} , Pr_{aij} and Co_{aij} :Yield, price and production cost (main and by-products)of each crop pertaining to crop sequence (a) , respectively.

Y_{bLK} ,Pr_{bLK} and Co_{bLK} : Yield, price and production cost (main and by- products) of each crop pertaining to crop sequence (b) , respectively.

D_a and D_b : Crop sequence (a) and crop sequence (b) durations by days, respectively.

The computation of the yield advantage (or disadvantage) net return of sequence "*a*" is as follows :

Yield advantage (or disadvantage) net return = ± LE/F.

=(NR of the evaluated sequence "*a*") – (NR of the compared sequence "*b*") **.**

= (Gross income –total costs of evaluated seq.) - (Gross income –total costs of compared seq.)

Evaluation of a sequence in comparison with relay intercropping system from the perspective of crop intensification:

Economical Yield Advantage Ratio $_{(seq / relay.)}$ (EYAR $_3$) :

$$EYAR_3 = [(\sum_{i=1}^{n} (\sum_{j=1}^{n^-} (Y_{aij}\, Pr_{aij}) - Co_{ai}))\, D_b]\, [(\sum_{L=1}^{m} (\sum_{K=1}^{m^-} Y_{bLk}\, Pr_{bLk}) - \sum_{L=1}^{m} Co_{bL})\, D_a]^{-1}$$

(El-Hawary , **2009**) **……………….. (11)**

Economical Yield Advantage Ratio as percentage = (($EYAR_1$) -1)x 100= + %

Economical Yield Advantage Ratio$_{(sequ/ relay.)}$ as percentage= (($EYAR_3$) -1)x 100= + %

On account of applying the $EYAR_3$ equation ,the sequence that wished to evaluation should be occupied the formula numerator , while the relay intercropping that used as a comparing should be occupied the denominator of formula .

n : number of crops pertaining to crop sequence (a) . n^- : number of main and by-products together of the crop . Which n^- varies according to each crop (where $n^-=ni$). .

m: number of crops pertaining to relay intercropping system (b) . m^- : number of main and by products together of the crop . Which m^- varies according to each crop (where $m^-=mL$).

Y_{aij} , Pr_{aij} and Co_{aij} :Yield, price and production cost (main and by- products)of each crop pertaining to crop sequence (a) , respectively.

Y_{bLK} ,Pr_{bLK} and Co_{bLK} : Yield, price and production cost (main and by- products) of each crop pertaining to relay intercropping system (b) , respectively.

D_a and D_b :Crop sequence (a) and relay intercropping system (b) durations by days, respectively.

The computation of the yield advantage (or disadvantage) net return of sequence "*a*" is as follows :

Yield advantage (or disadvantage) net return = ± LE/F.

=(NR of the evaluated sequence "*a*") – (NR of the compared sequence "*b*") **.**

= (Gross income –total costs of evaluated seq.) - (Gross income –total costs of compared seq.)

<u>Evaluation of relay intercropping comparing with another relay intercropping system from the perspective of crop intensification:</u>

Economical Yield Advantage Ratio (relay/ relay.) (EYAR 4) :

$$EYAR\ 4=[(\sum_{i=1}^{n}(\sum_{j=1}^{n^-} Y_{aij}\, Pr_{aij})-\sum_{i=1}^{n} Co_{ai})\, D_b]\ [(\sum_{L=1}^{m}(\sum_{K=1}^{m^-} Y_{bLkj}\, Pr_{bLk})-\sum_{L=1}^{m} Co_{bL})\, D_a]^{-1}$$

(El-Hawary , **2009**) **……………... (10)**

Economical Yield Advantage Ratio as percentage = ((EYAR 4) -1)x 100= + %

Concerning $EYAR_4$ equation the relay intercropping that is wished to be evaluated takes up the numerator of the formula ,while the other relay intercropping which well be used as a comparative should be occupy the formula .

n : number of crops pertaining to relay intercropping system (a) . n^- : number of main and by-products together of the crop . Which n^- varies according to each crop (where $n^-=ni$)..

m: number of crops pertaining to relay intercropping system (b) . m^- : number of main and by-products together of the crop . Which m^- varies according to each crop (where $m^-=mL$). .

Y_{aij} , Pr_{aij} and Co_{aij} :Yield, price and production cost (main and by- products)of each crop pertaining to relay intercropping system (a) , respectively.

Y_{bLK} ,Pr_{bLK} and Co_{bLK} : Yield, price and production cost (main and by- products) of each crop pertaining to relay intercropping system (b) , respectively.

D_a and D_b : Relay intercropping system (a) and relay intercropping system (b) durations by days, respectively.

The computation of the yield advantage (or disadvantage) net return of sequence "*a*" is as follows :

Yield advantage (or disadvantage) net return = ± LE/F.

=(NR of the evaluated sequence "*a*") – (NR of the compared sequence "*b*") **.**

= (Gross income –total costs of evaluated seq.) - (Gross income –total costs of compared seq.)

Economic **L**and **E**quivalent **R**atio ($ELER_1$):

$$\mathbf{ELER_1 = (Y_{a1} \times Y_a^{-1}) + (Y_{a2} \times P_{r2})\,(Y_o \times Pry)^{-1} + (C_o - C_1)\,(Y_o \times Pry)^{-1}}$$

(El-Hawary,**1993**)……………… **(9)**

Where:

Y_o =Yield / Fadden of the crop that substituted by intercropping crops and , also, is one of the crops that used in the intercropping (Yo $=Y_a$)

Y_{a1} = The production of the major intercropped crop..

Y_a = The production of the same major crop cultivated alone .

P_{ry} = The price of the production unit of y_o .

Y_{a2} = The production of the secondary intercropped crop.

P_{r2} = The price of the production unit of y_{a2} .

C_o = Total costs of y_o .

C_1 = Total costs of intercropping (included : fertilizers , labors , pesticide control , seeds …..etc.)

Data obtained from chemical analysis, as well as other data obtained from literature, were used to establish a mathematical equation to reduce the IEP of gliadin, glutenin, and gluten (the major important proteins from the stand-point of (bread making) with information about glutamic + aspartic (A) and lysine + arginine (B) amino acids content as follows:

IEP = 2.553 + 3.000 log A/B (El-Hawary *et al* ,**1989**) …………**(8)**

where :

IEP = the isoelectric point of gliadin, glutenin, or gluten.

A = glutamic + aspartic amino acids.

B = lysine + arginine amino acids.

2.533 and 3.000 = constants.

Differences between values calculated from the above suggested equation and those obtained from chemical analysis are not significant.

Data obtained from titration curves of protein as well as other data obtained from literature were used to establish mathematical equation to predict the IEP of protein with information about soluble protein percent of total extracted protein in the initially prepared alkaline extract at pH 1.0 as follows :

IEP = 4.9895 – 1.1000 Log . R/10. (El-Hawary , **1988**) ………**(7)**

Where : IEP is the iso –electric point of protein .

R is soluble protein percent of total extracted protein in the initially prepared alkaline extracted at pH 1.0 . while 10 is a factor.

4.9895 and 1.1000 are constants .

Differences between values calculated from equation and those obtained from titration curves are not significant . Information obtained from the above mentioned equation are valid from 30 to 100% of total extracted protein at pH 1.0 .

Data obtained from chemical analysis were used to establish mathematical equation to deduce the ash and protein contents of flour at 85% extraction rate with information about ash and protein contents of whole grains as follow :

For ash : **Y = X / (0.76711 + 0.41071 X)**

(El-hawwary and Abd-awwad,**1983)…….(6)**

where :

Y= ash content of flour at 85 % extraction rate.

X= ash content of grains .

0.76711 and 0.41071 are constants

For protein : **Y = X / (1.02293 + 0.00551 X)……………………………….(5)**

Where: Y= protein content of flour at 85% extraction rate .

X= protein content in grains .

1.2293 and 0.00551 are constants .

Differences between values obtained from above equations and those of chemical analysis showed non significant differences at the level of 0.01 for ash and protein . Moreover , correlation between ash and protein contents of flour at 85% extraction rate and ash and protein contents of flour at 70% extraction rate were proved mathematically as follow :

For ash : **Y = X / (2.5568 - 0.1754 X)…………………………………….(4)**

where :

Y= ash content of flour at 70 % extraction rate.

X= ash content of flour at 85% extraction rate..

2.5568 and 0.1754 are constants .

For protein : $\mathbf{Y = X / (1.20953 - 0.0003425\ X)}$…………………………**(3)**

Where: Y= protein content of flour at 70% extraction rate .

X= protein content at 85 % extraction rate ..

1.20953 and 0.0003425 are constants .

Differences between values obtained mathematically and those of chemical analysis were not significant at the level of 0.01 for ash and protein .

Data obtained from chemical analysis as well as other data obtained from literature were used to establish mathematical equation to deduce the IEP of protein with information about glutamic + asparatic (A) and lysine +arginine (B) amino acids content as follows:

$IEP = 3.73 + 1.79\ \text{Log.}\ A/B$ (El-hawwary and Abd-awwad,**1983**)………**(2)**

Where ; IEP is the iso-electric point of true protein.

A is glutamic + asparatic amino acids .

B is lysine + arginine amino acids .

3.73 and 1.79 are constants.

Differences between values calculated from above suggested equation
and those obtained from chemical analysis are not significant .

Equation for simulation (obtaining values conformed with the values of commercial roller mills government).

The equation was as follows :

$Y - [\ ((-b+X)/X)\ \ Y\ ] = Ym$ (El-Hawary, **1977**)……….**(1)**

Where :

X = The percent of ash or protein or ….. etc. of laboratory mill of American wheat.

b = The percent of ash or protein or ….. etc. of roller mill of American wheat.

Y = The percent of ash or protein or ….. etc. of laboratory mill of flour varieties (Chenab 70 , Maxibak 69 and Gizza 155) .

Ym = The percent of ash or protein or …. Etc. after correction .

This coefficient was also obtained at every extraction rates .

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