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Introducing a novel natural logarithmic indices and their corresponding percentages table towards quantitative estimation of plant tolerance levels to stressors

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Abstract

The methods of evaluating tolerance levels of plants to stressors for many years have been based on indices and visual based scores which are more of descriptive and qualitative. Despite their ease of use the strategies have demonstrated errors arising from different researchers levels of perception and biases in judgment. This has resulted to inaccuracies in the generated data leading to poor monitoring and forecasting of plant stresses, especially in plant tolerance evaluations against diseases. Moreover, these techniques have been limited to the observation of one if not a few parameters separately, ignoring the complexity and dynamics of plant responses to stressors which in many cases affects different parameters of the plant variably. Despite, the development of computer imaging systems, the problem of cost and availability for developing countries is a challenge. Therefore, the objective of this study was to develop a cheap quantitative host plant tolerance levels estimation technique which is based on logarithmic efficacy indices generation and a table that can be used to predict their corresponding percentages that incorporates a novel concept known as IPLI (Integrated Parameter Logarithmic Indexing). The strategy integrates three parameters that are affected by stress significantly and generates holistic indices whose corresponding percentages estimate tolerance levels. Napier stunt disease infected napier grass treatments of accession 16789 and Bana variety were used to demonstrate how the technique works. Basing on the preliminary results their tolerance levels were estimated at 29.86% and 12.59% respectively. The approach looks promising in quantitative evaluation of the trait.

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Introduction

The use of descriptive indices and visual based scoring techniques in host plant tolerance levels estimation to stressors has been used for a long time due to their ease of use and convenience. However, these strategies are prone to errors that arise from different researcher's abilities in making judgments during assigning of appropriate visual scores representing a certain damage class of plants due to the stress factor (Reese and Schwenke, 1994; Mutka and Bart, 2015). These challenges have compromised the use of the data from such evaluation strategies due to reduced precision, accuracy and reliability in monitoring and forecasting of the stressors towards their proper management (Bock *et al.*, 2010). The use of computer imaging systems seems promising however their availability and cost to developing economies poses a greater challenge (Mutka and Bart, 2015).

Qualitative strategies which have been used in estimating tolerance levels entail; Kawubee*et al.*(2014) estimation approach in napier grass infected by napier stunt disease pathogen. In this method they used visual scoring strategies based on morpho-pathological characteristics whose final means were subjected to a model by Zouzou *et al.* (2008). The formula then estimated the damage levels of the disease and tolerance magnitude in percentage of the various napier grass varieties. Despite the ease of using the method, it generally exhibits errors which emanate from the variations observed among individual rating abilities in the initial stages (Reese and Schwenke, 1994; Bock *et al.*, 2010). Additionally, the approach does not incorporate many parameters of a plant for an all-inclusive assessment of the plant's tolerance abilities, now that they tend to be very unstable due to their genotype, varying seasons, locations, management practices and stages of growth (Zhu *et al.*, 1996; John, 1998; Francl, 2001; Keane, 2012; Surico, 2013; Turano*et al.*, 2016; Negawo *et al.*, 2017). The above challenges are also observedon other reported methods of estimating tolerance using indices (Morgan *et al.*, 1980; Bramel-cox *et al.*, 1986; Dixon *et al.*, 1990; Robinson *et al.*, 1991; Fernandez, 1992; Formush *et al.*, 1992). Therefore, the more parameters involved in evaluation of an entity like tolerance, the closer the estimation will be to the true mean statistically (Zar, 2010). Therefore, this study sought to develop a quantitative tolerance estimation technique that integrates three parameters that significantly correlate with a plant's productivity towards a possible consistent and accurate estimator of a plant's tolerance against a stress factor.

Materials and methods

This study entailed the generation of natural logarithmic indices' and their corresponding percentages table demonstrated on table 5. Then an algorithm that generates the natural logarithmic indices was developed shown on table 1. The natural logarithmic indices once generated where then assigned their corresponding logarithmic percentages from the table 5. A preliminary experimental data involving two napier grass varieties as a plant case study; namely accession 16789 and Bana variety were used to demonstrate how the developed table and algorithm works in quantitatively estimating the tolerance levels of a plant system. The twonapier grass germplasm were evaluated in 2× 2 factorial experiment in completely randomized design under glasshouse conditions. The factors studied were; (i.) Inoculation/infection states at 2 levels namely; napier stunt pathogen (NSD)-inoculated and uninoculated (Control). (ii.) Napier grass varieties at 2 levels namely; accession 16789 and Bana variety. This gave a total of 4 treatments which were replicated six times to give a total of 24experimental units. The accession 16789 and Bana variety were used in this study because they had been selected as tolerant and susceptible to napier stunt disease respectively (Wamalwa *et al.*, 2015; Wamalwa *et al.*, 2017). The napier grass canes under the different treatments were planted in 20cm diameter pots containing black forest soil and watered daily upon inoculation with napier stunt pathogen ('*Candidatus* Phytoplasma oryzae' strain Mbita 1). The Napier plants were inoculated using a protocol described by Obura *et al.* (2009) and Wamalwa *et al.* (2017). Upon inoculation and incubation the napier grass were harvested after

24 weeks. The parameters measured were total fresh biomass (yield), the tillers height (plant height) and their chlorophyll levels, as they are affected significantly by stress in this case the disease which was the source of the same (Kabirizi *et al.*, 2015).

Generation of a natural logarithmic indices' and their corresponding percentages table

The estimation of relative host plant tolerance levels of a plant in challenging exposure to a stress situation was made possible by exploiting the logarithmic scales which exist between absolute numbers (test system ability numbers)that enabled assigning of corresponding logarithmic percentages as shown on table 5(Thomas, 1998; Umbarger, 2006). This led to the generation of *'Omatec natural logarithmic indices' and their corresponding percentages table* (illustrated as table 5) that integrated three logarithmic percentage scales in what holistically was termed as *triple scaling strategy* (three scales integration approach). The table 5 enabled the determination of corresponding logarithmic percentages of the two types of indices (M.E.I and M.L.I) that estimated the efficacy in performance of a plant under different forms of stress.

The generation of the *'Omatec natural logarithmic indices' and their corresponding percentages table'* (Table 5) was made possible by taking advantage of the integer value one which has logarithmic value of zero (since, each living system begins life from a unit value or single cell) and the relative indices it generates when it doubles, triples etc. This is because regardless of an organism's size or units used to measure it; a relative change that doubles or triples and so on is assigned the same magnitude index by logarithms (Causton and Venus, 1981; Hunt, 1982; Parry, 1990; Thomas, 1998; Hunt *et al.*, 2002; Umbarger, 2006). Therefore, using excel sheet the test system ability numbers were generated using one (1) as a reference point so that the resulting corresponding efficacy indices' percentages were consecutive in a continuum manner as shown in column C on sheet 1 of Fig. 4. The logarithmic indices responsible for the corresponding percentages were generated using the integer 1 as the initial performance value using the index generation function demonstrated on the excel screenshot shown on sheet 2 of Fig. 5.

Then using relativity the natural logarithmic value of one (which is zero) was subtracted from all the natural logarithms of the test system ability numbers generated to obtain an efficacy index for each test ability's number using the logarithmic quotient rule (Thomas, 1998; Umbarger, 2006). Finally, the indices were assigned corresponding percentages using the function shown on the excel screenshot on sheet 3 (Fig. 6), leading to the first scale of the three scales. The deviation percentage (specific tolerance power) was obtained by a function shown on the excel screenshot of sheet 4 (Fig. 7), leading to the second logarithmic scale of the three scales. This deviation described the levels by which a plant adjusted its processes when stressed towards managing the situation. Graph of the percentages corresponding to the efficacy indices was generated to test accuracy of the values in predicting magnitude of a system by observing the level of spacing on the generated trend (the less the spacing the high the accuracy of the table values likelihood in predicting any index's percentage) as shown on Fig.1 and 2 of the results chapter. Third scale of the three scales was determined relative to the highest natural logarithmic index (14.51) to estimate each of the logarithmic indices power relative to it in a linear trend as shown on Fig.3. The corresponding percentage levels were determined by dividing each natural logarithmic index as numerator by 14.51 as the denominator, with the quotient/answer being multiplied by 100%. The mean percentage of these three scales in the 'Omatec natural logarithms indices' and their corresponding percentages table' shown on table 5, described the mean corresponding logarithmic percentage whose values were corrected by subtracting 16.67% and multiplying the answer by 1.200048; that is the function ((mean corresponding percentage – 16.67%) × 1.200048); which corrected the percentages to give the absolute value 1 its zero percent magnitude leading to the fulfillment of the rationale described earlier based on Wolpert (2011). This corrected the mean corresponding percentages synonymous to host plant tolerance/resistance of plant system.

An algorithm for determining the natural logarithmic index of a plant's tolerance levels to stress relative to its control using a modified apparent infection rate model

This formula was developed to aid in the generation of a natural logarithmic index which estimates a plant's performance in tolerating a stressor. The generated natural logarithmic index's corresponding percentage was then determined from the generated *'Omatec natural logarithmic indices' and their corresponding percentages table'* shown on table 5. The efforts towards addressing this was based on the premise that; mean yield of a plant, its mean height and chlorophyll levels being components of cumulative input of growth process and being affected significantly by stressors could therefore be used to estimate the potential of a plant to resist or tolerate a certain stress source (Causton and Venus, 1981; Hunt, 1982). Further, resistance or tolerance being a relative trait to a control or a highly susceptible end of a plant population system (in case of a diseases attack) using relativity it can be quantified (Freeman and Beattie, 2008). Therefore, three significantly affected parameters (yield, terminal growth of a plant and chlorophyll levelssince it correlates with photosynthesis levels) were integrated in the modified formula by Parry (1990) and Andrivon *et al.* (2006), towards determination of the natural logarithmic index of a plant's performance relative to its control. The *algorithms 2a, 2b, 2c* and *2d* shown on table 1, integrated the three plant's vital parameters through logarithmic indexing which was the point of modification (IPLC; Integrated Parameter Logarithmic Indexing). This estimated a plant's mean efficacy index (M.E.I) value, which was the mean index performance of a potential plant relative to its controls as shown on table 1. Another critical value was the performance of a plant relative to its unit value (1) or zero potential abbreviated (M.L.I) mean logarithmic index.

The rationale behind the two indices was as follows; the first index M.E.I; (magnitude efficacy index) generated by *algorithm 2a, 2b,* and *2c* (Table 1); described the plant's magnitude of change from their respective normal/control; that is their respective stress free controlupon exposure to a stress factor (Table 1). The second index M.L.I; (mean logarithmic index) described the plant's magnitude of change from the unit value (1) whose logarithmic index is zero, which was equated to a zero potential/level. The index was generated by getting the mean of the respective natural logarithms of the three parameters that influence plant performance significantly and their percentage determined directly from the 'Omatec natural logarithmic indices' and their corresponding percentages table' (Table 5).

The (M.L.I) index generation was based on the premise supported by Wolpert (2011), that an organism before initiation of growth and development it exhibits zero potential in any aspect. This potential is then unlocked up on exposure to suitable environmental conditions that favour growth. However, basing on the interaction of the varying plant genotypes and the environmental conditions, a living organism ends up exhibiting different levels or potentials in growth vigour. Thus, if this vigour could be estimated using relativity to unit value (1) whose logarithmic value is zero, then the impact of the environmental exposure can be estimated and the plant's effort (tolerance levels) against the exposure determined. As a result, this led to the M.L.I index that estimated the magnitude of change of a plant's performance from zero potential to maximum potential of growth basing on the logarithmic quotient rule where the denominator is unit value (1). The rule states that any logarithmic value of a quotient of any absolute number (A) relative to unit value (1), where (A) is the numerator and one is the denominator. The logarithmic value of the resulting quotient is equal to the logarithmic value of (A) (Thomas, 1998; Umbarger, 2006). Therefore, using this argument the productive/growth potential of a plant under a particular stressor versus its productive/growth potential minus the stressor was estimated using logarithmic relativity a concept that has been used extensively to study plant growth dynamics (Hunt *et al*., 2002). The logarithm value zero was equated to a zero potential of an organism before any active response to an input. This was possible because efficacy indices generated by *algorithm 2a, 2b, 2c*and*2d* are a product of relativity where the standard performance; that is the outputs of the plant when not stressed was compared with its performance when stressed using natural logarithms. Thus, the mean percentages (mean %) of the respective corresponding logarithmic percentages of the M.E.I and M.L.I indices of each treatment were determined from the developed '*Omatec natural logarithmic indices' and their corresponding percentages table*' (Table5).

Statistical analysis

This study describes a novel approach that can be used to quantify the tolerance levels of a plant in percentage terms which then can be subjected to many other statistical analysis ranging from descriptive to inferential statistics as demonstrated in the results and discussion section.

Results and discussion

The cohort of three scales determined using triple scaling approach

The tripling scaling approach that was used in estimating the host plant resistance/tolerance was made up of three percentage scales that were integrated to give a holistic evaluation through their means.

Table 1. The models used to estimate the mean logarithmic indices. The indices are then used to determine their corresponding logarithmic percentages (mean %) from 'Omatec natural logarithmic indices' and corresponding percentages table' towards quantitative estimation of tolerance magnitude levels of plants.

Algorithm 2a.

(L.I.S or L.I.I); Logarithmic Index Stressed or Logarithmic Index Inoculated (for diseased plant)

$$= \frac{(\mathrm{LN}(\mathrm{TFWi} \times \mathrm{TLHi} \times \mathrm{CHi}))}{3}$$

Algorithm 2b.

(L.I.C/L.I.U); Logarithmic Index Control (OR) Logarithmic Index Uninoculated (for non − diseased plant)

$$= \frac{(\mathrm{LN}(\mathrm{TFWc} \times \mathrm{TLHc} \times \mathrm{CHc}))}{3}$$

Algorithm 2c.

(M.E.I); Magnitude Efficacy Index

$$\mathrm{M.E.I} = \text{Logarithmic Index Stressed} - \text{Logarithmic Index Control}$$

(OR)

$$\mathrm{M.E.I} = \text{Logarithmic Index Inoculated} - \text{Logarithmic Index Uninoculated}$$

Algorithm 2d.

Mean Corresponding Logarithmic Percentage (Mean %)

$$(\text{Mean }\%) = \frac{(\text{M.E.I corresponding logarithmic }\%) + (\text{M.L.I corresponding logarithmic }\%)}{2}$$

Where: (LN) was the natural logarithm of a respective plant's means of its total fresh weight in grams, height in centimeters and chlorophyll levels in SPAD units of the stressed plant's performance denoted as (TFWi), (TLHi) and (CHi) respectively. The resulting output was added and the average determined by dividing by three (3), since they were three parameter values. The components (TFWc), (TLHc), and (CHc) described the unstressed plant's mean performance of its total fresh weight, height and chlorophyll levels. The average was also determined by dividing by three (3). The modified logarithmic infection rate algorithm estimated the magnitude efficacy index (M.E.I) for the plant regardless whether there was a biomass decrease or increase without introducing a math error scenario due to the defined function's range to domain limitation. It is important to note that the (L.I.I or L.I.S) and (L.I.C or L.I.U) are sub-types of M.L.I (mean logarithmic index). The sub-types arise because of the different treatment conditions a plant might be subjected to in an experiment. The M.L.I and M.E.I corresponding percentages were determined from the '*Omatec natural logarithmic indices' and their corresponding percentages table* (Table 5).

Table 2. The mean performance of two napier grass germplasm under inoculation and uninoculation states demonstrating how the mean logarithmic indices (M.L.I) are obtained by determining the natural logarithm of the respective parameters performance, then the average of the three forms the M.L.I index.

Napier grass variety/accession evaluated	Total fresh biomass in grams (Mean Yield)	Tiller height in cm (Mean Plant Height)	Chlorophyll levels in SPAD units (Mean levels)	M.L.I
16789 accession (Inoculated with NSD)	220.88 ± 1.10 (LN220.88) = 5.40	155.96 ± 1.03 (LN155.96) = 5.05	35.29 ± 1.04 (LN35.29)= 3.56	4.67
16789 accession (Uninoculated control)	423.38 ± 1.12 (LN423.38) = 6.05	280.72 ± 1.08 (LN280.72) = 5.64	43.45 ± 1.05 (LN43.45)= 3.77	5.15
Bana variety (Inoculated with NSD)	76.55 ± 1.09 (LN 76.55) = 4.34	60.12 ± 1.15 (LN 60.12) = 4.10	15.65 ± 1.05 (LN15.65)= 2.75	3.73
Bana variety (Uninoculated control)	472.27 ± 1.14 (LN 472.27)= 6.16	300.84 ± 1.11 (LN 300.84)= 5.71	48.23 ± 1.07 (LN48.23)= 3.88	5.25

Therefore, the three scales utilized a continuum of test systems' ability absolute numbers shown on column B of table 5. The highest system number was 2,000,000 and the lowest was 0.000,000,001 as shown on column B (Table 5). The test sytems' numbers in column B represented the ability of a system performance for example row number 163 (column A), coincides with the test number (2) of column B which represents the ability of a system to double its normal/initial levels or effort in response to a factor or treatment. Where the initial levels in this case was unit value (1) on column B that is captured on row number 130 (column A) of table 5. This was possible because the natural logarithmic constant of any system to double is a constant regardless of its initial value.

Table 3. The table shows how the respective napier grass germplasm's Magnitude efficacy indices (M.E.I) were obtained from M.L.I indices using the algorithm described on table 1.

Napier grass varieties evaluated	M.L.I	M.E.I
16789 accession (Inoculated with NSD)	4.67	-0.48 Determined basing on relative performance;(4.67- 5.15) = -0.48
16789 accession (Uninoculated control)	5.15	
Bana variety (Inoculated with NSD)	3.73	-1.52 Determined basing on relative performance;(3.73- 5.25) = -1.52

Table 4. The corresponding logarithmic percentages of the M.L.I and M.E.I were then determined from the '*Omatec natural logarithms indices' and their corresponding percentages table'* whose averages or mean percentage is shown on the far right as (mean %) or host plant tolerance levels in percentage.

Napier grass variety/accession evaluated	M.L.I	M.L.I Corresponding logarithmic %	M.E.I	M.E.I Corresponding logarithmic %	Mean % or Host plant tolerance %
16789 accession (Inoculated with NSD)	4.67	75.23%	-0.48	-15.52%	29.86%
Bana variety (Inoculated with NSD)	3.73	67.84%	-1.52	-42.66%	12.59%

These constants were also observed to exist in cases of tripling, quadrupling and quintupling (Causton and Venus, 1981; Hunt, 1982;Parry, 1990; Thomas, 1998; Hunt *et al*., 2002; Umbarger, 2006).

First scale of the three (triple) scales determined

The first scale of a cohort of three scales, determined the overall maximum potential in percentage upon an input/treatment relative to the absolute value one whose logarithmic potential is zero (Fig.1). This scale produced a continuum of values whose maximum percentage value was 100% (Fig.1), that corresponded with natural logarithmic index 14.51 shown on column (C) of the 'Omatec Logarithmic Indices' and their Corresponding Percentages Table' shown on table 5.

Table 5. Omatec logarithmic indices' and their corresponding percentages table; for estimating host plant tolerance to stressors.

Column A	Column B	Column C	Column D	Column E	Column F	Column G	Column H
Row number	Test-system's ability in absolute values	Natural logs (ln) efficacy (Indices)	(Scale 1) Overall maximum potential in percentage upon an input	(Scale 2) Specific input potential in percentage	(Scale 3) Percentage levels of logarithmic indices relative to the highest logarithmic index (14.51)	Mean percentage of the three scales Columns D, E & F X%	Corrected mean percentage of the three scales giving the corresponding logarithmic (%) (correction function) (X% – 16.67) × 1. 200048
1.	0	*	0.00	-100.00	*	*	*
2.	0.000000001	-20.72	0.00	-100.00	-142.80	-80.93	-117.12
3.	0.000122071	-9.01	0.01	-99.98	-62.10	-54.02	-84.83
4.	0.000244141	-8.32	0.02	-99.95	-57.34	-52.42	-82.91
5.	0.000294141	-8.13	0.03	-99.94	-56.03	-51.98	-82.38
6.	0.000366211	-7.91	0.04	-99.93	-54.51	-51.47	-81.77
7.	0.000488281	-7.62	0.05	-99.90	-52.52	-50.79	-80.96
8.	0.000549317	-7.51	0.05	-99.90	-51.76	-50.54	-80.66
9.	0.000610352	-7.40	0.06	-99.88	-51.00	-50.27	-80.33
10.	0.000732422	-7.22	0.07	-99.85	-49.76	-49.85	-79.83
11.	0.000782422	-7.15	0.08	-99.84	-49.28	-49.68	-79.62
12.	0.000854493	-7.07	0.09	-99.83	-48.73	-49.49	-79.40
13.	0.000976563	-6.93	0.10	-99.80	-47.76	-49.15	-78.99
14.	0.001126563	-6.79	0.11	-99.77	-46.80	-48.82	-78.59
15.	0.001220704	-6.71	0.12	-99.76	-46.24	-48.63	-78.36
16.	0.001330704	-6.62	0.13	-99.73	-45.62	-48.41	-78.10
17.	0.001440704	-6.54	0.14	-99.71	-45.07	-48.21	-77.86
18.	0.001464844	-6.53	0.15	-99.71	-45.00	-48.19	-77.84
19.	0.001564844	-6.46	0.16	-99.69	-44.52	-48.02	-77.63
20.	0.001664844	-6.40	0.17	-99.67	-44.11	-47.87	-77.45
21.	0.001764844	-6.34	0.18	-99.65	-43.69	-47.72	-77.27
22.	0.001953125	-6.24	0.19	-99.61	-43.00	-47.47	-76.97
23.	0.002953125	-5.82	0.29	-99.41	-40.11	-46.41	-75.70
24.	0.00390625	-5.55	0.39	-99.22	-38.25	-45.69	-74.83
25.	0.00490625	-5.32	0.49	-99.02	-36.66	-45.06	-74.08
26.	0.005859375	-5.14	0.58	-98.83	-35.42	-44.56	-73.48
27.	0.0068125	-4.99	0.68	-98.65	-34.39	-44.12	-72.95
28.	0.0078125	-4.85	0.78	-98.45	-33.43	-43.70	-72.45
29.	0.0088125	-4.73	0.87	-98.25	-32.60	-43.33	-72.00

30.	0.0098125	-4.62	0.97	-98.06	-31.84	-42.98	-71.58
31.	0.01171875	-4.45	1.16	-97.68	-30.67	-42.40	-70.89
32.	0.013671875	-4.29	1.35	-97.30	-29.57	-41.84	-70.21
33.	0.015625	-4.16	1.54	-96.92	-28.67	-41.35	-69.63
34.	0.01953125	-3.94	1.92	-96.17	-27.15	-40.47	-68.57
35.	0.0234375	-3.75	2.29	-95.42	-25.84	-39.66	-67.60
36.	0.02734375	-3.60	2.66	-94.68	-24.81	-38.94	-66.73
37.	0.03125	-3.47	3.03	-93.94	-23.91	-38.27	-65.93
38.	0.0390625	-3.24	3.76	-92.48	-22.33	-37.02	-64.43
39.	0.046875	-3.06	4.48	-91.04	-21.09	-35.88	-63.06
40.	0.05078	-2.98	4.83	-90.33	-20.54	-35.35	-62.43
41.	0.0546875	-2.91	5.19	-89.63	-20.06	-34.83	-61.80
42.	0.0625	-2.77	5.88	-88.24	-19.09	-33.82	-60.59
43.	0.0685	-2.68	6.41	-87.18	-18.47	-33.08	-59.70
44.	0.07031	-2.65	6.57	-86.86	-18.26	-32.85	-59.43
45.	0.078125	-2.55	7.25	-85.51	-17.57	-31.94	-58.33
46.	0.085025	-2.46	7.84	-84.33	-16.95	-31.15	-57.39
47.	0.088125	-2.43	8.10	-83.80	-16.75	-30.82	-56.99
48.	0.09375	-2.37	8.57	-82.86	-16.33	-30.21	-56.26
49.	0.1	-2.30	9.09	-81.82	-15.85	-29.53	-55.44
50.	0.109375	-2.21	9.86	-80.28	-15.23	-28.55	-54.27
51.	0.11719	-2.14	10.49	-79.02	-14.75	-27.76	-53.32
52.	0.12	-2.12	10.71	-78.57	-14.61	-27.49	-52.99
53.	0.125	-2.08	11.11	-77.78	-14.33	-27.00	-52.41
54.	0.13	-2.04	11.50	-76.99	-14.06	-26.52	-51.83
55.	0.140625	-1.96	12.33	-75.34	-13.51	-25.51	-50.62
56.	0.143	-1.94	12.51	-74.98	-13.37	-25.28	-50.34
57.	0.15	-1.90	13.04	-73.91	-13.09	-24.65	-49.59
58.	0.15625	-1.86	13.51	-72.97	-12.82	-24.09	-48.91
59.	0.165	-1.80	14.67	-71.67	-12.41	-23.14	-47.77
60.	0.171875	-1.76	14.67	-70.67	-12.13	-22.71	-47.26
61.	0.18	-1.71	15.25	-69.49	-11.78	-22.01	-46.42
62.	0.1875	-1.67	15.79	-68.42	-11.51	-21.38	-45.66
63.	0.196	-1.63	16.39	-67.22	-11.23	-20.69	-44.83
64.	0.203125	-1.59	16.88	-66.23	-10.96	-20.10	-44.13
65.	0.208	-1.57	17.22	-65.56	-10.82	-19.72	-43.67
66.	0.21875	-1.52	17.95	-64.10	-10.48	-18.88	-42.66
67.	0.22	-1.51	18.03	-63.93	-10.41	-18.77	-42.53
68.	0.234375	-1.45	18.99	-62.03	-9.99	-17.68	-41.22
69.	0.2421875	-1.42	19.50	-61.01	-9.79	-17.10	-40.53
70.	0.25	-1.39	20.00	-60.00	-9.58	-16.53	-39.84
71.	0.255	-1.37	20.32	-59.36	-9.44	-16.16	-39.40
72.	0.258	-1.35	20.51	-58.98	-9.30	-15.92	-39.11
73.	0.27	-1.31	21.26	-57.48	-9.03	-15.08	-38.10

74.	0.28125	-1.27	21.95	-56.10	-8.75	-14.30	-37.17
75.	0.28225	-1.26	22.01	-55.98	-8.68	-14.22	-37.07
76.	0.296875	-1.21	22.89	-54.22	-8.34	-13.22	-35.87
77.	0.3	-1.20	23.08	-53.85	-8.27	-13.01	-35.62
78.	0.3125	-1.16	23.81	-52.38	-7.99	-12.19	-34.63
79.	0.319	-1.14	24.18	-51.63	-7.86	-11.77	-34.13
80.	0.328125	-1.11	24.71	-50.59	-7.65	-11.18	-33.42
81.	0.34	-1.08	25.37	-49.25	-7.44	-10.44	-32.53
82.	0.34375	-1.07	25.58	-48.84	-7.37	-10.21	-32.26
83.	0.359375	-1.02	26.44	-47.13	-7.03	-9.24	-31.09
84.	0.369	-1.00	26.95	-46.09	-6.89	-8.68	-30.42
85.	0.375	-0.98	27.27	-45.45	-6.75	-8.31	-29.98
86.	0.385	-0.95	27.80	-44.40	-6.55	-7.72	-29.27
87.	0.395	-0.93	28.32	-43.37	-6.41	-7.15	-28.59
88.	0.40625	-0.90	28.89	-42.22	-6.20	-6.51	-27.82
89.	0.416	-0.88	29.38	-41.24	-6.06	-5.97	-27.17
90.	0.421875	-0.86	29.67	-40.66	-5.93	-5.64	-26.77
91.	0.4375	-0.83	30.43	-39.13	-5.72	-4.81	-25.78
92.	0.4475	-0.80	30.92	-38.17	-5.51	-4.25	-25.11
93.	0.4575	-0.78	31.39	-37.22	-5.38	-3.74	-24.49
94.	0.46875	-0.76	31.91	-36.17	-5.24	-3.17	-23.81
95.	0.478	-0.74	32.34	-35.32	-5.10	-2.69	-23.23
96.	0.484375	-0.72	32.63	-34.74	-4.96	-2.36	-22.84
97.	0.5	-0.69	33.33	-33.33	-4.76	-1.59	-21.91
98.	0.51	-0.67	33.77	-32.45	-4.62	-1.10	-21.32
99.	0.52	-0.65	34.21	-31.58	-4.48	-0.62	-20.75
100.	0.53125	-0.63	34.69	-30.61	-4.34	-0.09	-20.11
101.	0.546875	-0.60	35.35	-29.29	-4.14	0.64	-19.24
102.	0.5625	-0.58	36.00	-28.00	-4.00	1.33	-18.41
103.	0.57	-0.56	36.31	-27.39	-3.86	1.69	-17.98
104.	0.58	-0.54	36.71	-26.58	-3.72	2.14	-17.44
105.	0.59375	-0.52	37.25	-25.49	-3.58	2.73	-16.73
106.	0.61	-0.49	37.89	-24.22	-3.38	3.43	-15.89
107.	0.625	-0.47	38.46	-23.08	-3.24	4.05	-15.14
108.	0.63	-0.46	38.65	-22.70	-3.17	4.26	-14.89
109.	0.64	-0.45	39.02	-21.95	-3.10	4.66	-14.41
110.	0.65625	-0.42	39.62	-20.75	-2.89	5.33	-13.61
111.	0.67	-0.40	40.12	-19.76	-2.76	5.87	-12.96
112.	0.6875	-0.37	40.74	-18.52	-2.55	6.56	-12.13
113.	0.7	-0.36	41.18	-17.65	-2.48	7.02	-11.58
114.	0.71875	-0.33	41.82	-16.36	-2.27	7.73	-10.73
115.	0.73	-0.31	42.20	-15.61	-2.14	8.15	-10.22
116.	0.75	-0.29	42.86	-14.29	-2.00	8.86	-9.37
117.	0.76	-0.27	43.18	-13.64	-1.86	9.23	-8.93

118.	0.78125	-0.25	43.86	-12.28	-1.72	9.95	-8.06
119.	0.80	-0.22	44.44	-11.11	-1.52	10.60	-7.28
120.	0.8125	-0.21	44.83	-10.34	-1.45	11.01	-6.79
121.	0.83	-0.19	45.76	-9.29	-1.31	11.72	-5.94
122.	0.84375	-0.17	45.76	-8.47	-1.17	12.04	-5.56
123.	0.86	-0.15	46.24	-7.53	-1.03	12.56	-4.93
124.	0.875	-0.13	46.67	-6.67	-0.90	13.03	-4.37
125.	0.89	-0.12	47.09	-5.82	-0.83	13.48	-3.83
126.	0.90625	-0.10	47.54	-4.92	-0.69	13.98	-3.23
127.	0.9375	-0.06	48.39	-3.23	-0.41	14.92	-2.10
128.	0.96	-0.04	48.98	-2.04	-0.28	15.55	-1.34
129.	0.96875	-0.03	49.21	-1.59	-0.21	15.80	-1.04
130.	1	0.00	50.00	0.00	0.00	16.67	0.00
131.	1.03	0.03	50.74	1.48	0.21	17.48	0.97
132.	1.05	0.05	51.22	2.44	0.34	18.00	1.60
133.	1.0625	0.06	51.52	3.03	0.41	18.32	1.98
134.	1.09	0.09	52.15	4.31	0.62	19.03	2.83
135.	1.125	0.12	52.94	5.88	0.83	19.88	3.85
136.	1.14	0.13	53.27	6.54	0.90	20.24	4.28
137.	1.15625	0.15	53.62	7.25	1.03	20.63	4.75
138.	1.1875	0.17	54.29	8.57	1.17	21.34	5.60
139.	1.2	0.18	54.55	9.09	1.24	21.63	5.95
140.	1.23	0.21	55.16	10.31	1.45	22.31	6.77
141.	1.25	0.22	55.56	11.11	1.52	22.73	7.27
142.	1.28	0.25	56.14	12.28	1.72	23.38	8.05
143.	1.3125	0.27	56.76	13.51	1.86	24.04	8.84
144.	1.34	0.29	57.26	14.53	2.00	24.60	9.52
145.	1.375	0.32	57.89	15.79	2.21	25.30	10.36
146.	1.4	0.34	58.33	16.67	2.34	25.78	10.93
147.	1.4375	0.36	58.97	17.95	2.48	26.47	11.76
148.	1.46875	0.38	59.49	18.99	2.62	27.03	12.43
149.	1.48	0.39	59.68	19.35	2.69	27.24	12.68
150.	1.5	0.41	60.00	20.00	2.83	27.61	13.13
151.	1.55	0.44	60.78	21.57	3.03	28.46	14.15
152.	1.58	0.46	61.24	22.48	3.17	28.96	14.75
153.	1.625	0.49	61.90	23.81	3.38	29.70	15.64
154.	1.64	0.49	62.12	24.24	3.38	29.91	15.89
155.	1.6875	0.52	62.79	25.58	3.58	30.65	16.78
156.	1.72	0.54	63.29	26.47	3.72	31.16	17.39
157.	1.75	0.56	63.64	27.27	3.86	31.59	17.90
158.	1.8125	0.59	64.44	28.89	4.07	32.47	18.96
159.	1.83	0.60	64.66	29.33	4.14	32.71	19.25
160.	1.875	0.63	65.22	30.43	4.34	33.33	19.99
161.	1.9	0.64	65.52	31.03	4.41	33.65	20.38

162.	1.96	0.67	66.22	32.43	4.62	34.42	21.30
163.	2	0.69	66.67	33.33	4.76	34.92	21.90
164.	2.0625	0.72	67.35	34.69	4.96	35.67	22.80
165.	2.08	0.73	67.53	35.06	5.03	35.87	23.04
166.	2.125	0.75	68.00	36.00	5.17	36.39	23.66
167.	2.22	0.80	68.94	37.89	5.51	37.45	24.94
168.	2.25	0.81	69.23	38.46	5.58	37.76	25.31
169.	2.3	0.83	69.70	39.39	5.72	38.27	25.92
170.	2.375	0.86	70.37	40.74	5.93	39.01	26.81
171.	2.395	0.87	70.54	41.09	6.00	39.21	27.05
172.	2.5	0.92	71.43	42.86	6.34	40.21	28.25
173.	2.55	0.94	71.83	43.66	6.48	40.66	28.79
174.	2.625	0.97	72.41	44.83	6.69	41.31	29.57
175.	2.7	0.99	72.97	45.95	6.82	41.91	30.29
176.	2.75	1.01	73.33	46.67	6.96	42.32	30.78
177.	2.8	1.03	73.68	47.37	7.10	42.72	31.26
178.	2.875	1.06	74.19	48.39	7.31	43.30	31.96
179.	2.95	1.08	74.68	49.37	7.44	43.83	32.59
180.	3	1.10	75.00	50.00	7.58	44.19	33.03
181.	3.125	1.14	75.76	51.52	7.86	45.05	34.06
182.	3.25	1.18	76.47	52.94	8.13	45.85	35.02
183.	3.3	1.19	76.74	53.49	8.20	46.14	35.37
184.	3.375	1.22	77.14	54.29	8.41	46.61	35.93
185.	3.5	1.25	77.78	55.56	8.61	47.32	36.78
186.	3.625	1.29	78.38	56.76	8.89	48.01	37.61
187.	3.75	1.32	78.95	57.89	9.10	48.65	38.38
188.	3.875	1.35	79.49	58.97	9.30	49.25	39.10
189.	3.9	1.36	79.59	59.18	9.37	49.38	39.25
190.	4	1.39	80.00	60.00	9.58	49.86	39.83
191.	4.125	1.42	80.49	60.98	9.79	50.42	40.50
192.	4.25	1.45	80.95	61.90	9.99	50.95	41.14
193.	4.375	1.48	81.40	62.79	10.20	51.46	41.75
194.	4.5	1.50	81.82	63.64	10.34	51.93	42.31
195.	4.625	1.53	82.22	64.44	10.54	52.40	42.88
196.	4.75	1.56	82.61	65.22	10.75	52.86	43.43
197.	4.875	1.58	82.98	65.96	10.89	53.28	43.93
198.	5	1.61	83.33	66.67	11.10	53.70	44.44
199.	5.125	1.63	83.67	67.35	11.23	54.08	44.89
200.	5.25	1.66	84.00	68.00	11.44	54.48	45.37
201.	5.375	1.68	84.31	68.63	11.58	54.84	45.81
202.	5.5	1.70	84.62	69.23	11.72	55.19	46.23
203.	5.625	1.73	84.91	69.81	11.92	55.55	46.66
204.	5.75	1.75	85.19	70.37	12.06	55.87	47.04
205.	5.875	1.77	85.45	70.91	12.20	56.19	47.43

206.	6	1.79	85.71	71.43	12.34	56.49	47.79
207.	6.125	1.81	85.96	71.93	12.47	56.79	48.15
208.	6.25	1.83	86.21	72.41	12.61	57.08	48.49
209.	6.375	1.85	86.44	72.88	12.75	57.36	48.83
210.	6.5	1.87	86.67	73.33	12.89	57.63	49.15
211.	6.625	1.89	86.89	73.77	13.03	57.90	49.48
212.	6.75	1.91	87.10	74.19	13.16	58.15	49.78
213.	6.875	1.93	87.30	74.60	13.30	58.40	50.08
214.	7	1.95	87.50	75.00	13.44	58.65	50.38
215.	7.125	1.96	87.69	75.38	13.51	58.86	50.63
216.	7.25	1.98	87.88	75.76	13.65	59.10	50.92
217.	7.375	2.00	88.06	76.12	13.78	59.32	51.18
218.	7.5	2.01	88.24	76.47	13.85	59.52	51.42
219.	7.625	2.03	88.41	76.81	13.99	59.74	51.69
220.	7.75	2.05	88.57	77.14	14.13	59.95	51.94
221.	7.875	2.06	88.73	77.46	14.20	60.13	52.15
222.	8	2.08	88.89	77.78	14.33	60.33	52.39
223.	8.125	2.09	89.04	78.08	14.40	60.51	52.61
224.	8.25	2.11	89.19	78.38	14.54	60.70	52.84
225.	8.375	2.13	89.33	78.67	14.68	60.89	53.07
226.	8.5	2.14	89.47	78.95	14.75	61.06	53.27
227.	8.625	2.15	89.61	79.22	14.82	61.22	53.46
228.	8.75	2.17	89.74	79.49	14.96	61.40	53.68
229.	8.875	2.18	89.87	79.75	15.02	61.55	53.86
230.	9	2.20	90.00	80.00	15.16	61.72	54.06
231.	9.125	2.21	90.12	80.25	15.23	61.87	54.24
232.	9.25	2.22	90.24	80.49	15.30	62.01	54.41
233.	9.375	2.24	90.36	80.72	15.44	62.17	54.60
234.	9.5	2.25	90.48	80.95	15.51	62.31	54.77
235.	9.625	2.26	90.59	81.18	15.58	62.45	54.94
236.	9.75	2.28	90.70	81.40	15.71	62.60	55.12
237.	9.875	2.29	90.80	81.61	15.78	62.73	55.27
238.	10	2.30	90.91	81.82	15.85	62.86	55.43
239.	10.125	2.32	91.01	82.02	15.99	63.01	55.61
240.	10.25	2.33	91.11	82.22	16.06	63.13	55.75
241.	11	2.40	91.67	83.33	16.54	63.85	56.62
242.	12	2.48	92.31	84.62	17.09	64.67	57.60
243.	13	2.56	92.86	85.71	17.64	65.40	58.48
244.	14	2.64	93.33	86.67	18.19	66.06	59.27
245.	15	2.71	93.75	87.50	18.68	66.64	59.97
246.	16	2.77	94.12	88.24	19.09	67.15	60.58
247.	17	2.83	94.44	88.89	19.50	67.61	61.13
248.	18	2.89	94.74	89.47	19.92	68.04	61.65
249.	19	2.94	95.00	90.00	20.26	68.42	62.10
250.	20	3.00	95.24	90.48	20.68	68.80	62.56

251.	22	3.09	95.65	91.30	21.30	69.42	63.30
252.	25	3.22	96.15	92.31	22.19	70.22	64.26
253.	30	3.40	96.77	93.55	23.43	71.25	65.50
254.	35	3.56	97.22	94.4	24.53	72.05	66.46
255.	40	3.69	97.56	95.12	25.43	72.70	67.24
256.	50	3.91	98.04	96.08	26.95	73.69	68.43
257.	60	4.09	98.36	96.72	28.19	74.42	69.30
258.	70	4.25	98.59	97.18	29.29	75.02	70.02
259.	80	4.38	98.77	97.53	30.19	75.50	70.60
260.	90	4.50	98.90	97.80	31.01	75.90	71.08
261.	100	4.61	99.01	98.02	31.77	76.27	71.52
262.	1000	6.91	99.90	99.80	47.62	82.44	78.93
263.	10000	9.21	99.99	99.98	63.47	87.81	85.37
264.	100000	11.51	100.00	100.00	79.32	93.11	91.73
265.	1000000	13.82	100.00	100.00	95.24	98.41	98.09
266.	1500000	14.22	100.00	100.00	98.00	99.33	99.20
267.	2000000	14.51	100.00	100.00	100.00	100.00	100.00

The symbol (*) indicates that the value generated on that cell is negative infinity. The Column B; displays the different abilities that living systems can exhibit in response to different stressors like a disease etc. Example Row Number 163; Column B; the number (2) represents the ability of a system to double its normal/initial levels or effort in response to a factor relative to a control, unit value or a standard. The Columns (C); displays the corresponding derived natural logarithm of the system's absolute values relative the unit value (1) or a control/standard. Example Row Number 163; Column (C); the logarithmic value is 0.69 which is the value one gets when a system doubles using natural logarithms. The Column (D); displays the corresponding overall percentages of the logarithmic values basing on their absolute values. Example Row Number 163; Column (D); equivalent percentage is 66.67%. The Column E; displays the specific percentage/ percentage deviation of a living system from a normal/standard. Example Row Number 163; Column (E); the deviation/specific percentage (power) is 33.33% for a system that doubles its normal/initial levels or effort in response to a factor. The specific percentage(specific power) demonstrates the effort an organism/system produces due to a response to environmental dynamics. The Column F; displays the percentage levels of logarithmic indices relative to the highest logarithmic index value namely 14.51 for natural logs shown on row 267 column (C). The Column (G); demonstrates the average magnitude of a system basing on the three percentages namely; overall percentage (Column D), specific percentage (Column E) and logarithmic indices percentages (Column F). The mean corresponding logarithmic percentage (Column G) was corrected using a function ((X% – 16.67) × 1. 200048), which gave the corrected mean corresponding logarithmic percentages in (Column H) that agrees with the rationale of the idea which was based on Wolpert (2011), as described in the materials and methods. The factor 1.200048 on the correction factor was determined by subtracting the highest value in Column G, which was 100% minus 16.67% which resulted to 83.33%. Therefore, by dividing 100% by 83.33% the correction factor 1.200048 was arrived at which was then used to correct all the values in Column G. Further, the value 16.67% in the correction model was the mean corresponding percentage of test system value (1) in Column B row number 130. Since, the logarithmic potential of (1) is zero which translates to 0% potential. Therefore, the correction function enabled the establishment of such a trend as shown on Column H. The table is read by comparing a natural logarithmic index of choice in Column C with its mean corresponding percentage in Column H. And if the logarithmic index is not directly captured on the table the two logarithmic indices where it falls in between, their mean corresponding logarithmic percentage is captured as an estimate of the corresponding percentage of the index in question from Column H.

Whereas the lowest percentage value was 0% (Fig.1), that corresponded also with natural logarithmic index -20.72 as shown on column (C) of 'Omatec Logarithmic Indices' and their Corresponding Percentages Table' (Table5). That meant that the highest and lowest potentials a biological system could manage logarithmically relative to unit value one (1) was 100% and 0% respectively. These values are captured in column (D) (table 5). This first scale exhibited the overall potential of a system in performance without taking into consideration the specific increase or decrease in potential levels of a system relative to unit value (1) whose logarithmic potential is zero. Therefore, the problem of specific deviation was evaluated using the second scale.

Second scale of the three (triple) scales determined

The second scale of the three of the triple scaling approach estimated the specific input potential in percentage upon an input/treatment relative to the absolute value one whose logarithmic potential was zero (Fig.2). Also, this scale produced a continuum of values whose maximum percentage value was 100% (Fig.2), that corresponded with natural logarithmic index 14.51 shown on column (C) of the 'Omatec Logarithmic Indices' and their Corresponding Percentages Table' (Table 5*)*. Whereas the lowest percentage value for this scale was -100% (Fig.2), that corresponded also with natural logarithmic index -20.72 shown on column (C) of *'Omatec Logarithmic Indices' and their Corresponding Percentages Table'* (Table5*)*. That meant that the highest and lowest specific input potentials a biological system exhibits in response to a treatment led to either an increase or a decrease logarithmically relative to unit value one (1).

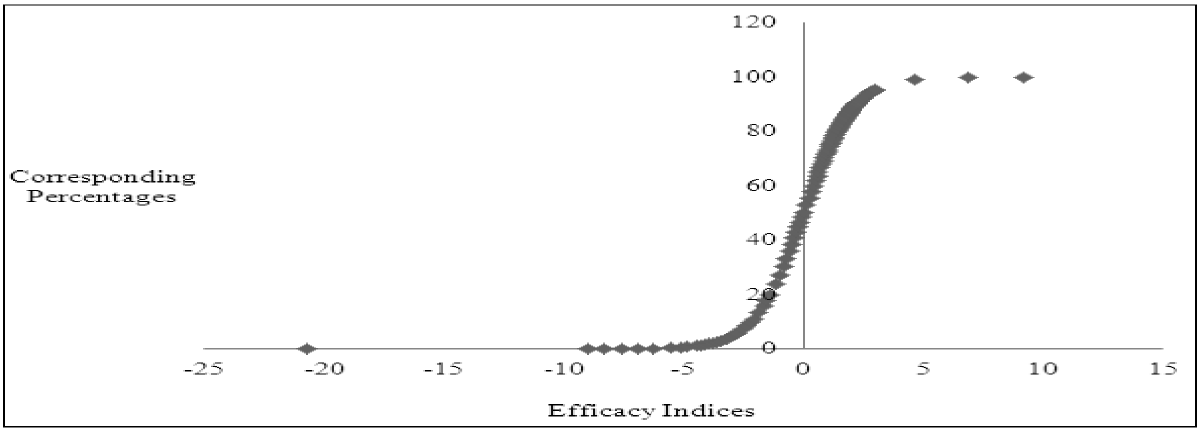


Fig. 1. A plot validating the closely placed logarithmic plots of corresponding overall maximum potential in percentage levels against natural logarithmic efficacy indices. The linear equation (y = 23.682x + 50.096) describes the exponential phase/linear phase of the curve whose coordinates' relationship strength stood at (R^2 = 0.9992). Confirming how close consecutive percentages are of different efficacy indices; increasing the reliability of the table in assigning percentage magnitudes of any unknown index on test. These generated indices and respective magnitudes in percentage were used to assign the host plant tolerance magnitudes basing on the relative performance of the stressed plant system from their unstressed controls. Details on different natural tolerance levels are shown on table 5*: Omatec Logarithmic Indices' and their Corresponding Percentages Table;* Column (D).

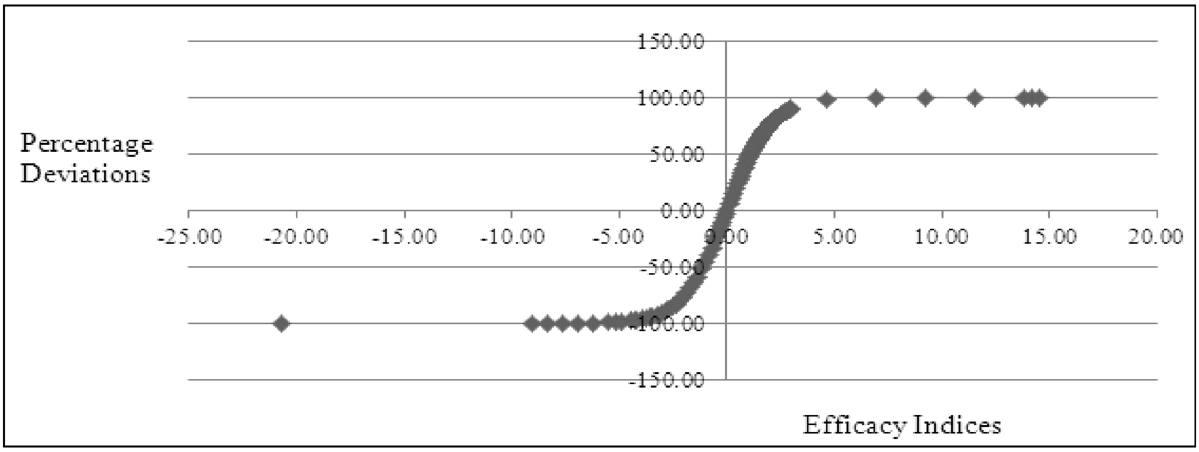


Fig. 2. A plot showing the logarithmic plot relationship between natural logarithmic efficacy indices of different levels and their equivalent specific input potential in percentages. These values estimate the levels in percentage of deviation of the stressed plant relative to their non-stressed controls; in terms of their plant processes mounting against the stress challenge. Details on different deviation levels are shown on table 5*: Omatec Logarithmic Indices' and their Corresponding Percentages Table*; Column (E). The concentration of the values consecutive to each other demonstrate the ability of the model to predict any other value with minimal error.

The negative in the lowest value (-100%) indicate a decline or decrease in the specific input potential. These values are captured in column (E) of the *'Omatec Logarithmic Indices' and their Corresponding Percentages Table'* (Table5). This second scale exhibited the specific increase or decrease in potential levels of a system relative to unit value (1) whose logarithmic potential is zero.

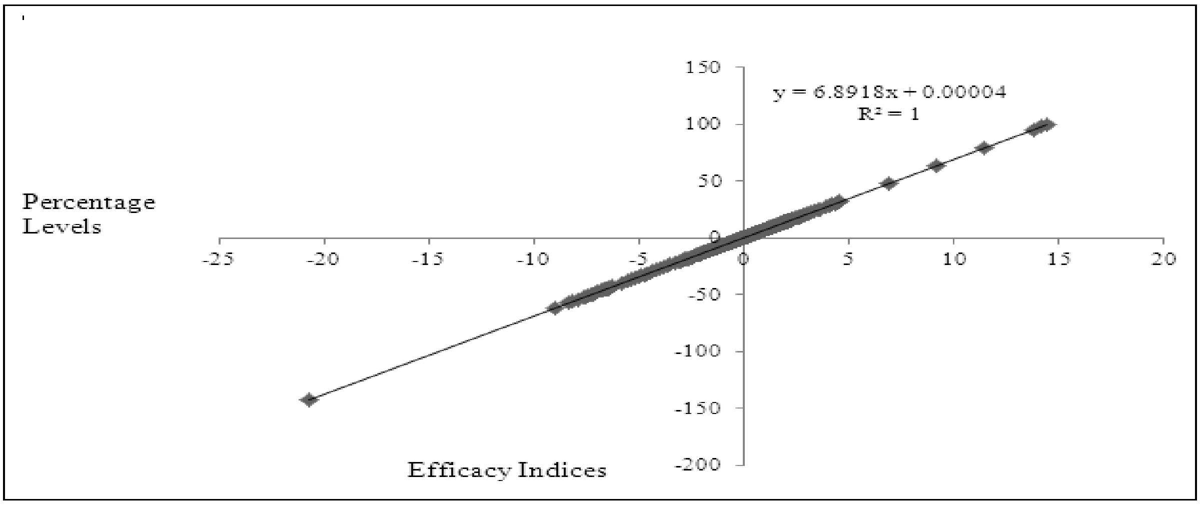
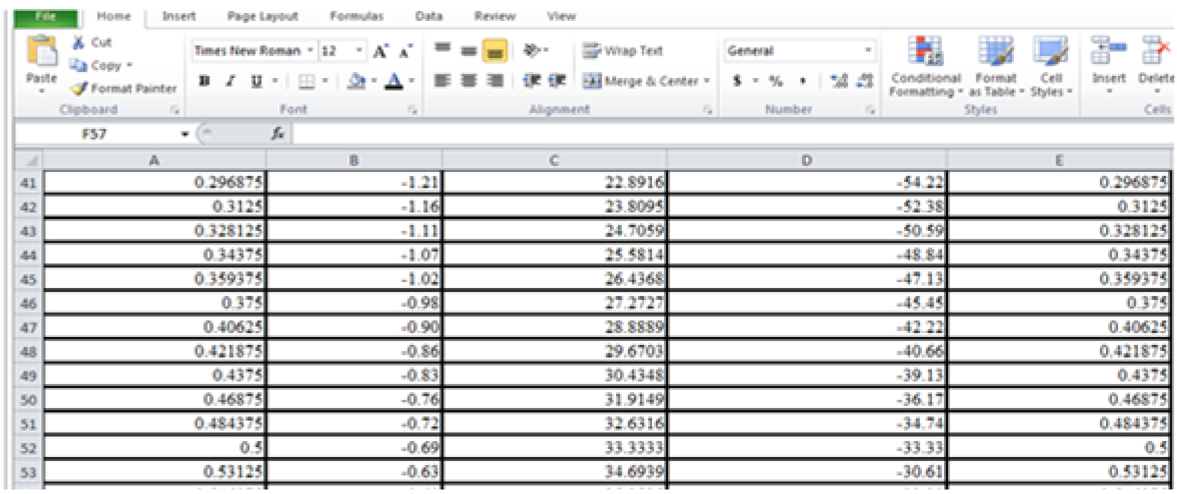


Fig. 3. A plot of corresponding percentage levels against their natural logarithmic efficacy indices obtained relative to the maximum logarithmic index (14.51). This maximum logarithmic index had a corresponding specific input percentage magnitude of 100% (table 5). These values estimate the power of respective logarithmic efficacy indices in percentage relative to the maximum index 14.51 value which is natural logarithm value of 2000000. The percentages were determined by dividing them as numerators by 14.51 as the denominator, with the answer being multiplied by 100%. Details on different percentage levels are shown on table 5*: Omatec Logarithmic Indices' and their Corresponding Percentages Table* Column (F). The concentration of the values consecutive to each other demonstrate the ability of the model to predict any other value within the continuum of values with high accuracy and reliability.

SHEET 1: Excel screenshot of omatec natural logarithms indices' table showing the test – system's ability numbers on column A. The numbers were generated to produce a continuum of corresponding consecutive percentages in column C.



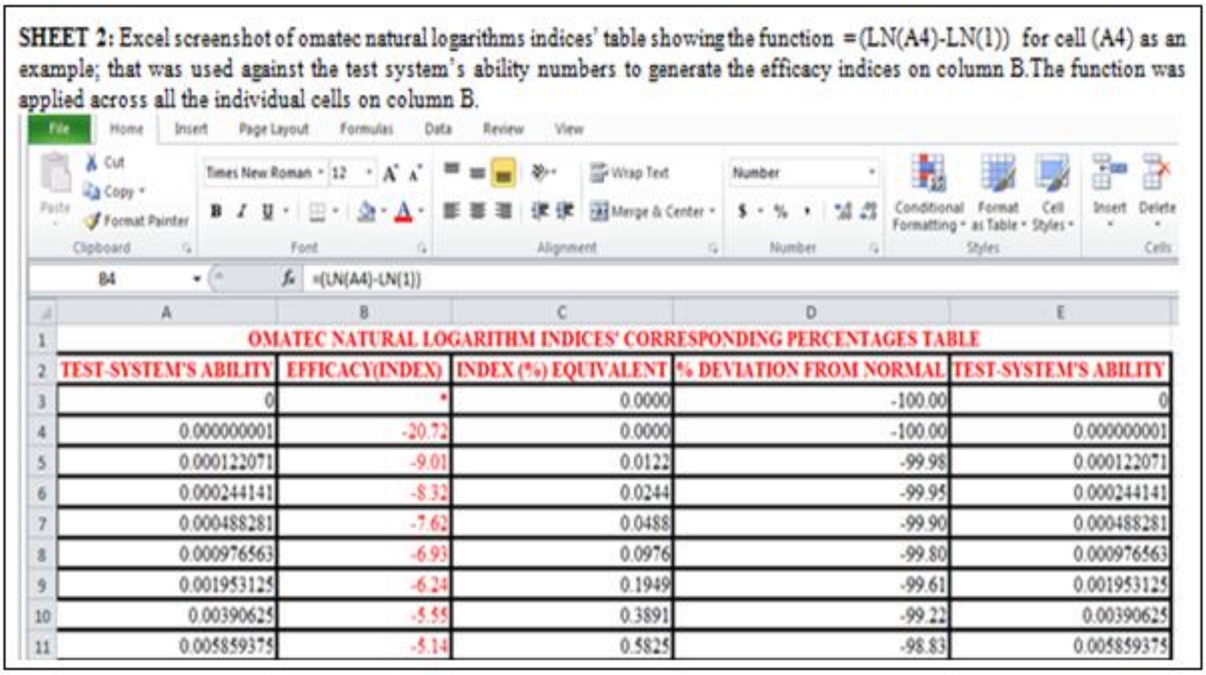
	A	B	C	D	E
41	0.296875	-1.21	22.8916	-54.22	0.296875
42	0.3125	-1.16	23.8095	-52.38	0.3125
43	0.328125	-1.11	24.7059	-50.59	0.328125
44	0.34375	-1.07	25.5814	-48.84	0.34375
45	0.359375	-1.02	26.4368	-47.13	0.359375
46	0.375	-0.98	27.2727	-45.45	0.375
47	0.40625	-0.90	28.8889	-42.22	0.40625
48	0.421875	-0.86	29.6703	-40.66	0.421875
49	0.4375	-0.83	30.4348	-39.13	0.4375
50	0.46875	-0.76	31.9149	-36.17	0.46875
51	0.484375	-0.72	32.6316	-34.74	0.484375
52	0.5	-0.69	33.3333	-33.33	0.5
53	0.53125	-0.63	34.6939	-30.61	0.53125

Fig. 4. Microsoft excel screenshot of sheet 1 showing the absolute values (test-system's ability numbers) on column A of the sheet 1. The numbers were generated to produce a continuum of corresponding consecutive percentages in column C of the sheet 1, towards development of the '*Omatec natural logarithms indices' and their corresponding percentages table'*

Third scale of the three (triple) scales determined

The third scale of the three of the triple scaling approach estimated the power/potential of each logarithmic index in percentage relative to the highest index 14.51 of the test ability number 2,000,000 that exhibited a perfect 100% for the first, second and third scales as shown on row number 267 of table 5. Also, this scale produced a continuum of values whose maximum percentage value was 100% whereas the lowest percentage value was -142.80% (Fig.3). The highest percentage value corresponded with natural logarithmic index 14.51 shown on column (C) of the 'Omatec Logarithmic Indices' and their Corresponding Percentages Table' (Table 5*)*. Whereas the lowest percentage value for this scale was -142.80% corresponded with natural logarithmic index -20.72 shown on column (C) (Table 5*)*.

That meant that the power of each index relative to the highest index was largely influenced by the type of the natural logarithm index of a particular test system absolute number relative to unit value (1).


SHEET 2: Excel screenshot of omatec natural logarithms indices' table showing the function =(LN(A4)-LN(1)) for cell (A4) as an example; that was used against the test system's ability numbers to generate the efficacy indices on column B.The function was applied across all the individual cells on column B.

B4 =(LN(A4)-LN(1))

OMATEC NATURAL LOGARITHM INDICES' CORRESPONDING PERCENTAGES TABLE

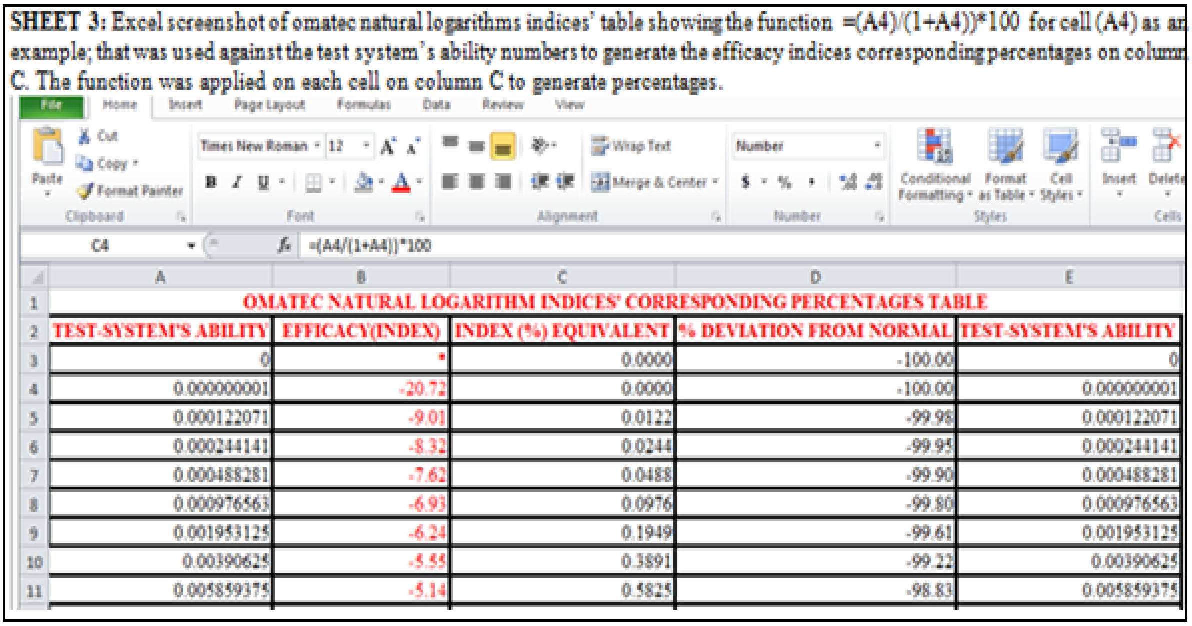
TEST-SYSTEM'S ABILITY	EFFICACY(INDEX)	INDEX (%) EQUIVALENT	% DEVIATION FROM NORMAL	TEST-SYSTEM'S ABILITY
0	*	0.0000	-100.00	0
0.000000001	-20.72	0.0000	-100.00	0.000000001
0.000122071	-9.01	0.0122	-99.98	0.000122071
0.000244141	-8.32	0.0244	-99.95	0.000244141
0.000488281	-7.62	0.0488	-99.90	0.000488281
0.000976563	-6.93	0.0976	-99.80	0.000976563
0.001953125	-6.24	0.1949	-99.61	0.001953125
0.00390625	-5.55	0.3891	-99.22	0.00390625
0.005859375	-5.14	0.5825	-98.83	0.005859375

Fig. 5. Microsoft excel screenshot of sheet 2 showing the function (= (LN (A4) - (LN (1)) used against the absolute values (test system's ability numbers) in column A of the sheet 2 to generate efficacy indices on Column B. The function was applied across all the individual cells on column B leading to the development of the '*Omate cnatural logarithms indices' and their corresponding percentages table.'*

That meant if it was a negative then definitely the power of the index was also to be a negative and vice-versa. These values are captured in column (F) of the *'Omatec Logarithmic Indices' and their Corresponding Percentages Table'* (Table 5)*,* whose linear trend is captured on Fig.3. The continuous trend arising from the mean of the three scales in column G of table5 before applying the correction function in column H of the same table could be attributed to the continuous nature of the absolute numbers which increases sequentially in continuous manner as demonstrated on Fig.1, 2 and 3.

This trend then simulates the continuum nature of the tolerance trait in a population of plants (Freedman and Beattie, 2008; Omayio *et al*., 2014).

According to Freedman and Beattie (2008), a plant's tolerance levels against a stressor can be determined from the continuum, if it's evaluated as a relative trait to the control. The trait varies continuously due to a huge environmental influence of the genes that quantitatively expresses the same (Keane, 2012).



SHEET 3: Excel screenshot of omatec natural logarithms indices' table showing the function =(A4)/(1+A4))*100 for cell (A4) as an example; that was used against the test system's ability numbers to generate the efficacy indices corresponding percentages on column C. The function was applied on each cell on column C to generate percentages.

C4 =(A4/(1+A4))*100

	A	B	C	D	E
1	OMATEC NATURAL LOGARITHM INDICES' CORRESPONDING PERCENTAGES TABLE				
2	TEST-SYSTEM'S ABILITY	EFFICACY(INDEX)	INDEX (%) EQUIVALENT	% DEVIATION FROM NORMAL	TEST-SYSTEM'S ABILITY
3	0	*	0.0000	-100.00	0
4	0.000000001	-20.72	0.0000	-100.00	0.000000001
5	0.000122071	-9.01	0.0122	-99.98	0.000122071
6	0.000244141	-8.32	0.0244	-99.95	0.000244141
7	0.000488281	-7.62	0.0488	-99.90	0.000488281
8	0.000976563	-6.93	0.0976	-99.80	0.000976563
9	0.001953125	-6.24	0.1949	-99.61	0.001953125
10	0.00390625	-5.55	0.3891	-99.22	0.00390625
11	0.005859375	-5.14	0.5825	-98.83	0.005859375

Fig. 6. Microsoft excel screenshot of sheet 3 showing the function (= (A4)/ (1+A4))*100) used against the absolute values (test system's ability numbers) in column A of sheet 3 to generate efficacy indices' corresponding percentages on Column C of the sheet 3. The function was applied on each cell on column C to generate percentages that led to the development of the '*Omatec natural logarithms indices' and their corresponding percentages table'*.

Development of a table predicting the corresponding logarithmic magnitudes in percentage

Finally, to develop a table that could predict the corresponding logarithmic magnitudes in percentage of a biological system. It meant harmonization of the trends of the three scales that ranged from logarithmic to linear trends. Therefore, the mean (average percentage magnitude) of the three scales was established and the various treatment combination's indices were subjected to the table to determine their corresponding mean logarithmic percentages as captured on column (G) of the *'Omatec Logarithmic Indices' and their Corresponding Percentages Table'* (Table 5). These means highest value was 100% that corresponded with the natural logarithmic index 14.51 and the lowest value was -80.93% that corresponded with the natural logarithmic index -20.72 as shown on column (C) (Table 5). However, since the corresponding percentage of absolute value 1 was 16.67% as shown on Column G (Table 5). A correction function ((X% – 16.67) × 1. 200048), was applied across the percentage values in Column G which corrected the trend to the one shown on Column H, where the corresponding percentage of absolute value (1) was reduced to 0%. The details on how the function was arrived at are shown on the description below the table 5. The harmonization of the three scales by determining their means enabled reduction of the error involved due to the different trends observed of the scales (Fig.1, 2 and 3). As a result, accuracy and reliability of the final scale in column H of table 5is increased significantly (Zar, 2010).

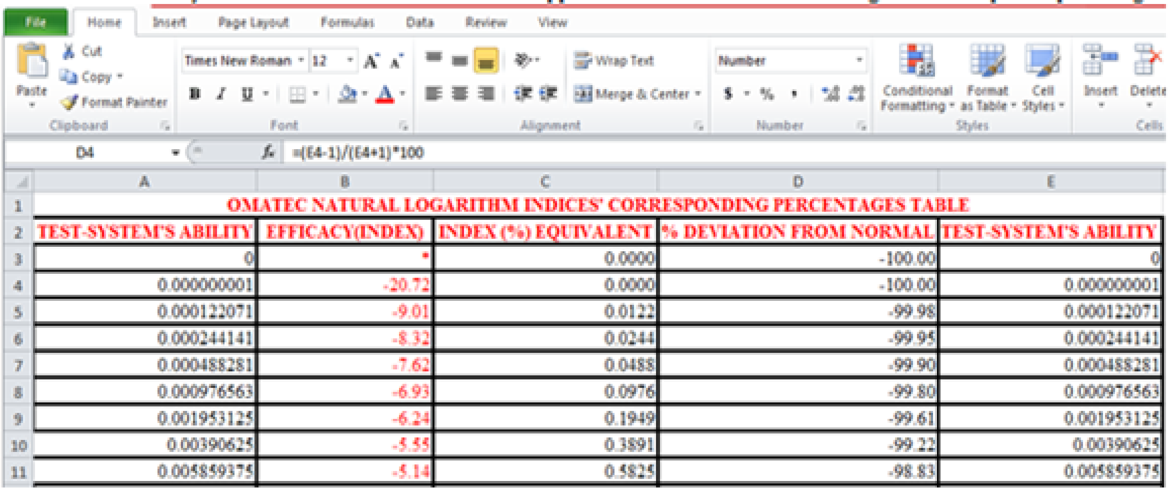
Using preliminary results on two napier grass varieties infected by napier stunt disease pathogen to demonstrate how the table can be used in estimating tolerance levels in percentage for a plant species under certain stress

Towards demonstration on how the *'Omatec Logarithmic Indices' and their Corresponding Percentages Table'* works (Table 5). The two napier grass germplasm (accession 16789 and Bana variety) used as case study were used. Accession 16789 had a mean logarithmic index (M.L.I) of 4.67 and 5.15, under inoculation and uninoculation states respectively (Table 2). Whereas, the susceptible check Bana variety had mean logarithmic index (M.L.I) of

3.73 and 5. 25 under inoculated and uninoculated states respectively (Table 2). This was the performance of the germplasm relative to unit value (1). On their performance relative to their controls accession 16789 magnitude efficacy index (M.E.I) was -0.48 as shown on table 3. The negative indicating a decline in performance due to the disease effect. Banavariety the susceptible check's magnitude efficacy index (M.E.I) was -1.52 as demonstrated on table 3.

Finally, the estimation of the corresponding logarithmic percentages of the respective indices from the *'Omatec Logarithmic Indices' and their Corresponding Percentages Table'* (Table 5) was performed.

SHEET 4: Excel screenshot of omatec natural logarithms indices' table showing the function =(E4-1)/(E4+1)*100 for cell (E4) as an example; that was used against the test system's ability numbers to generate the specific percentage /deviation percentage from the normal/standard of a system on column D. The function was applied for each cell in column D to generate the specific percentages.



	A	B	C	D	E
1	OMATEC NATURAL LOGARITHM INDICES' CORRESPONDING PERCENTAGES TABLE				
2	TEST-SYSTEM'S ABILITY	EFFICACY(INDEX)	INDEX (%) EQUIVALENT	% DEVIATION FROM NORMAL	TEST-SYSTEM'S ABILITY
3	0	*	0.0000	-100.00	0
4	0.000000001	-20.72	0.0000	-100.00	0.000000001
5	0.000122071	-9.01	0.0122	-99.98	0.000122071
6	0.000244141	-8.32	0.0244	-99.95	0.000244141
7	0.000488281	-7.62	0.0488	-99.90	0.000488281
8	0.000976563	-6.93	0.0976	-99.80	0.000976563
9	0.001953125	-6.24	0.1949	-99.61	0.001953125
10	0.00390625	-5.55	0.3891	-99.22	0.00390625
11	0.005859375	-5.14	0.5825	-98.83	0.005859375

Fig. 7. Microsoft excel screenshot of sheet 4 showing the function (= (E4-1)/ (E4+1)*100) used against the absolute values (test system's ability numbers) in column A of sheet 4 to generate the specific percentage/deviation percentages from the normal/standard of a system on column D of the sheet 4. The function was applied on each cell on column D to generate specific percentages that led to the development of the *'Omatec natural logarithms indices' and their corresponding percentages table'*

The inoculated accession 16789 whose (M.L.I) index was 4.67 falls between indices 4.61 and 6.91, on column C of table 5, whose corresponding logarithmic percentages in column H are 71.52% and 78.93% respectively. Therefore, to determine the corresponding percentage of the index 4.67 the average between the two percentages which is 75.23% was assigned to the index as shown on table 4. This was the same case with inoculated Bana variety which had an (M.L.I) index of 3.73 (Table 4). The inoculated Bana variety's index falls between indices 3.69 and 3.91, column C of table 5, whose corresponding logarithmic percentages in column H were 67.24% and 68.43% respectively. Therefore, the average of 67.84% between the two values was assigned as corresponding percentage of the index 3.73 (Table 4).

The corresponding logarithmic percentage of (M.E.I) index -0.48 of the accession 16789 falls between indices -0.49 and -0.47, as shown on column C of table 5, whose corresponding logarithmic percentages in column H are-15.89% and -15.14% respectively. Therefore, to determine the corresponding percentage of the index -0.48 of accession 16789 the average between the two percentages which is -15.52% was assigned to the index as shown on table 4. That of Bana variety index's -1.52 captured on column C; along row 76 (column A) was -42.66% as shown on column H of table 5. These two percentages means for the respective napier grass germplasma led to the determination of the respective plant tolerance levels in percentage as demonstrated on table 4. The accession 16789 mean percentage or host plant tolerance levels against napier stunt pathogen ('*Candidatus* Phytoplasma oryzae' strain Mbita 1)was 29.86%, whereas that of Bana variety was 12.59% as shown on table 4. These results verified the findings by Wamalwa *et al.*(2015) which reported of accession 16789 exhibiting some levels of tolerance against napier stunt disease pathogen in comparison to Bana variety which is relatively susceptible. Therefore, these results gave an indication of the likely quantification of host plant tolerance levels in plants against stressors, which is a shift from the conventional use of indices which are unquantifiable and prone to errors during visual scoring (Bock *et al.*, 2010).

Conclusion

There is a clear indication that using logarithmic relativity between a stressed plant system in comparison to its unstressed plant system; the level of tolerance can be quantified. This strategy of using logarithmic indexing and determination of their corresponding percentages from the generated table, enables a magnitude of performance to be established that is analyzable and consistent since, it does not depend on an individual rating abilities but on what is measured. Moreover, incorporation of many parameters allows for a holistic and all-inclusive approach of analysis that can give a reliable output about a plant. If integrated by other approaches of imaging then it can open new horizons of studying the trait tolerance in plants.

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