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FERTILIZER RECOMMENDATION ON A SOIL TEST BASIS FOR A TARGET YIELD OF *TERMINALIA TOMENTOSA* (ASAN) IN RANCHI (INDIA) ENVIRONMENTAL CONDITION

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ABSTRACT

A field experiment was conducted for formulating various fertilizer requirements of *Terminalia tomentosa* (Asan) plant based on Mitscherlich-Bray equation in Ranchi environmental conditions. There, were different levels of nutrient dose for each nutrient. Soil available nutrients were estimated and Asan leaf yields were recorded. The data were subjected to Mitscherlich-Bray equation: log (A - y) = log A- c(1)b - cx Where A = % theoretical maximum yield, y = actual yield obtained in q ha^{-1}, b = native soil test value in kg ha^{-1}, x = fertilizer nutrient applied in kg ha^{-1}, c(1) and c = constants i.e., efficiency of soil and fertilizer nutrients, respectively. The results showed the c1 value of K and Mn was found to be lower among the macro and micronutrients, respectively indicating soil K is less efficiently utilized by the Asan plant. The same was true in the case of the c1/c ratio. The fertilizer recommendation chart was prepared for macro and micronutrients. This chart would be highly helpful for the farmers, stakeholders and others concerned to evade the plants from the nutrient stress condition. In this case, to achieve 90 percent maximum theoretical yield of Asan plant in Ranchi soil series, one has to apply 142, 111, 81, 50 and 19 kg N ha^{-1} with soil test values of 50, 100, 150, 200 and 250 kg ha^{-1}. There is no nutrient fertilizer required when the soil test value shows more than 300 kg ha^{-1}. Akin to N, all other nutrients including macro and micronutrients prepared the fertilizer recommendation charts with different degrees of soil test value in this region.

Keywords : Asan, Mitscerilisch-Bray, Nutrient, Silk, Tasar

Introduction

Tasar silkworm, *Antheraea mylitta* Drury is subjugated for commercial *vanya* silk production in India. About 4.0 lakh families, mostly tribals, are directly or indirectly allied with this tasar sericulture in different states in tropical belt of the country. Although *Antheraea mylitta* is a polyphagous insect, it fond to feed *Terminalia arjuna* and *T. tomentosa* and these plants are designated as primary host plants of tasar silkworm. It is a hardy, perennial deep-rooted plant capable of thriving under diverse agro-climatic conditions. As these plants widely growing in dry land condition, major time of the year suffer from water and nutrient stress results in considerably reduces the leaf yield and quality of leaves in the tropics. Besides, genotypes and cultivation practices also affect quality and yield potential of leaves. Among them, nutrient management practices play a vital role.

Nearly two-third of the silk produced by silkworm is directly obtained from proteins of leaves. Hence, silkworm should be fed with good quality leaves in abundant quantity for the successful cocoon production (Vijaya *et al*., 2009). In this regard, application of optimum nutrient is one of the important inputs for increasing leaf yield. Proper nutrition is essential for satisfactory plant growth and production. The use of soil tests can help to determine the status of plant available nutrients to develop fertilizer recommendations to achieve optimum production. Efficient application of the correct types and amounts of fertilizers for the supply of the nutrients is an important part of achieving profitable yields.

To achieve this, precise fertilizer prescription should be considered for crop needs and nutrients already available in the soil (Singh and Singh, 2016). Fertilizer is one of the costliest inputs in agriculture and the use of right amount of fertilizer is fundamental for profitability and environmental protection (Kimetu *et al*., 2004). Traditionally, to determine the optimum fertilizer doses of most appropriate method is to apply fertilizer on the basis of soil test and crop response studies. Consequently, fertilizer recommendation programme should be combined with organic source of nutrients to prevent the depletion of soil and ambient ecosystem.

Hence, it is vital for applying optimum dose of nutrients to the host plants without endangering the ecosystem for maximum production of host plant leaf yield and sustainable tasar silk production.

Materials and Methods

Experiments were conducted at block plantation fields of *Terminalia tomentosa* at CTR&TI, Ranchi Jharkhand. The host plans were grown with separate sets of treatments imposed in the different experimental plots as mentioned nutrient treatments series (Table 1) along with FYM @ 12.5 mt ha^{-1} $year^{-1}$. All the experiments were critically designed in complete randomized block design with three replications.

The biomass yield were subjected to Mitscherlich-Bray equation, viz, log (A-y) = logA-c1b-cx based on the principle that native and added nutrients comprehend different efficiency factors (Bray, 1949); where, A-maximum yield possibility when all nutrients are present in adequate amounts but not in excess (this can be obtained by SLAN concept), y-yield obtained at some level of b, b-soil test index, c- efficiency factor (constant) for b, x- amount of fertilizer added to the soil, c1- efficiency factor for x (Bray, 1949). After finding the c1 and c values, the quantity of nutrients to be added to obtain maximum possible yield (Bray, 1949) could worked out for different soil test values. Based on the relationship between biomass yields, adding fertilizers and the amount of nutrient already present in the soil, information was generated on the efficiency factors for soil nutrient and fertilizers applied with reference to respective nutrients. Subsequently, the obtained data was subjected to Mitscherlich-Bray equation and Ready reckoners of all fertilizer application has been developed for obtaining targeted yield of tasar host plants for the common range of soil test values of available nutrient contents under different tasar growing zones.

Table 1 : Treatment details

N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	S & Mg (kg ha^{-1})	Fe (kg ha^{-1})	Zn (kg ha^{-1})	Mn (kg ha^{-1})	Cu (kg ha^{-1})	B (kg ha^{-1})
0	0	0	0	0	0	0	0	0
50	20	20	20	10	5	5	3	2.5
100	40	40	30	20	10	10	6	5.0
150	60	60	40	30	15	15	9	7.5
200	80	80	-	-	-	-	-	-
With a common dose of P and K @ 50 kg ha^{-1} and 50 kg ha^{-1}, respectively	With a common dose of N and K @ 100 kg ha^{-1} and 50 kg ha^{-1}, respectively	With a common dose of N and P @ 100 kg ha^{-1} and 50 kg ha^{-1}, respectively	With a common dose of NPK @ 100-50-50 kg ha^{-1}, respectively					

With a common dose of P and K @ 50 kg ha^{-1} and 50 kg ha^{-1}, respectively With a common dose of N and K @ 100 kg ha^{-1} and 50 kg ha^{-1}, respectively With a common dose of N and P @ 100 kg kg ha^{-1} and 50 kg ha^{-1}, respectively with a common dose of NPK @ 100-50-50 kg ha^{-1}, respectively.

Results and Discussion

The Mitscherlich – Bray equation was used to compute the leaf biomass yield of Asan plant. Using the equation, the theoretical maximum yield was found for different nutrients experiments obtained from the plot of log y against 1/x (Fig. 1&2). The c1 and c values were calculated for different nutrient experiments. Among the macronutrients, the c1 value for K was smaller compared to the c1 values of N, P, S and Mg which mean that soil K was less efficiently utilized by the Asan plant compared to the soil N, P, S and Mg (Table 2). The higher c1 value was found with Mg followed by S and P. The ratio c1/c indicates the response of Arjuna plant to fertilizer application. A higher ratio value means that the crop has a lesser response to the applied fertilizer, while a lower ratio value indicates a greater response of the crop to the applied fertilizer (Sonar & Babhulkar, 2002). The ratio c1/c of the K experiment was the lowest compared to the c1/c ratio values of the N, P, S and Mg experiments, indicating that Asan plant was more responsive to K fertilization than other macronutrients fertilization. In the case of micronutrients, the c1 value for Mn was smaller compared to the other micronutrients. The c1/c ratio for the Mn experiment was the lowest of other nutrients followed by Fe and B. The Zn was found to be a higher ratio of c1/c in this experiment (Table 3).

The findings of this study revealed that soil test alone is not a reliable basis for formulating fertilizer recommendations. This is because it was shown that even if the soil contained sufficient amounts of nutrients, it was only capable of producing 50-70 percent maximum possible yield. The study demonstrated that even if the soil had sufficient inherent amounts of nutrients, fertilization was still necessary for higher leaf biomass yield.

The widespread practice of using “blanket fertilizer recommendation” for a particular crop regardless of site or soil conditions is not only erroneous and unscientific, but it is also wasteful. It can lead to under or over fertilizer applications. The former will result in low and unprofitable yield, while the latter will increase production costs and can be detrimental to the environment in the long-term.

The Mitscherlich equation, in its classical or modified form, is a powerful tool for evaluating crop response to fertilization and for formulating fertilizer recommendations. The Mitscherlich-Bray modification incorporates not only crop response to fertilization but soil test values as well, thus, making the equation more useful in formulating site-specific fertilizer recommendations. According to Dudal and Roy (1995), the design and implementation of integrated nutrient management systems require some forms of conceptual, analytical and simulation models to serve as a framework for the integration of the different components of such management systems. The Mitscherlich equation is a useful tool for such a purpose.

Table 4 & 5 shows that fertilizer recommendations derived from the leaf yield data of the different experiments using the Mitscherlich-Bray equation. These recommendations could provide a choice for a yield target depending on the inherent soil fertility levels. For example, fertilizer recommendations for soil with soil fertility of N=50, P=5 and K=50 kg ha^{-1} would be 90, 36 and 33 kg ha^{-1}, respectively to attain 80 percent of the maximum yield. Similarly, fertilizer recommendation charts for other nutrients have also been given to attain 80, 85 and 90 percent of the maximum theoretical yield. This result indicates that with an increase in soil test values for the different nutrients, there was a corresponding decrease in the nutrients. For achieving the maximum targeted yield as fixed in this study as 90 percent, one has to apply 142, 111, 81, 50, and 19 kg ha^{-1} with soil test values of 50, 100, 150, 200 and 250kg N ha^{-1}, respectively (Table 4). Likewise, fertilizer recommendations for other nutrients were given with a different range of soil test values against the different percent of the theoretical yield of leaf biomass. It is credible to enhance the fertilizer use efficiency and economize its use for sustainable Tasar silk production. To achieve high percentage relative yields, the equation can very well be suited under the conditions of low to high soil fertility. This has an added advantage in determining fertilizer requirements under a high buildup of available nutrients in successful cropping. This could serve as a wonderful tool for fertilizer recommendations for sustainable Tasar silk production.

Table 2 : Leaf yields of *Terminalia tomentosa* and efficiency coefficients of soil and fertilizer macronutrients (N, P, K, S, Mg) as experiment conducted in CTR & TI, Ranchi

Treatments (x)	Actual leaf yield over 50 leaves (g)	Calculated log Y	1/x	c1	c	c1/c
N applied kg ha^{-1}						
0	473	2.6749	0.0000	0.0036	0.0000	0.6126
50	527	2.7218	0.0200		0.0055	
100	574	2.7589	0.0100		0.0093	
150	569	2.7551	0.0067		0.0053	
200	560	2.7480	0.0050		0.0031	
Mean					0.0058	
Theoretical maximum yield (A): 587.49 g						
P_2O_5 applied kg ha^{-1}						
0	478	2.6794	0.0000	0.0295	0.0000	1.9353
20	556	2.7451	0.0500		0.0157	
40	591	2.7716	0.0250		0.0149	
60	621	2.7931	0.0167		0.0208	
80	603	2.7803	0.0125		0.0095	
Mean					0.0152	
Theoretical maximum yield (A): 587.49 g						
K_2O applied kg ha^{-1}						
0	499	2.6981	0.0000	0.0032	0.000	0.1947
20	568	2.7543	0.0500		0.0196	
40	607	2.7832	0.0250		0.0288	
60	591	2.7716	0.0167		0.0114	
80	573	2.7582	0.0125		0.0055	
Mean					0.0163	
Theoretical maximum yield (A): 615.18 g						
Sulphur applied kg ha^{-1}						
0	469	2.6712	0.0000	0.0373	0.000	2.1323
20	541	2.7332	0.0500		0.0399	
30	551	2.7412	0.0333		0.0458	
40	547	2.7380	0.0250		0.0263	
Mean					0.0373	
Theoretical maximum yield (A): 554.63 g						
Magnesium applied kg ha^{-1}						
0	489	2.6893	0.0000	0.12140	0.0326	3.2041
20	548	2.7388	0.0500		0.0531	
30	563	2.7505	0.0333		0.0277	
40	559	2.7474	0.0250		0.0378	
Mean					0.0326	
Theoretical maximum yield (A): 564.94 g						

Table 3 : Leaf yields of *Terminalia tomentosa* and efficiency coefficients of soil and fertilizer micronutrients (Fe, Zn, Mn, Cu, Zn) as experiment conducted in CTR & TI., Ranchi

Treatments (x)	Actual leaf yield over 50 leaves (g)	Calculated log Y	1/x	c1	c	c1/c
Fe applied kg ha^{-1}						
0	473	2.6749	0.0000	0.0212	0.0000	0.4236
10	555	2.7443	0.1000		0.0534	
20	583	2.7657	0.0500		0.0649	
30	567	2.7536	0.0333		0.0242	
Mean					0.0475	
Theoretical maximum yield (A): 588.84 g						
Zn applied kg ha^{-1}						
0	473	2.6749	0.0000	1.1118	0.0000	13.3962
5	541	2.7332	0.2000		0.0925	
10	569	2.7551	0.1000		0.1126	
15	554	2.7435	0.0667		0.0439	
Mean					0.0830	
Theoretical maximum yield (A): 576.77 g						
Mn applied kg ha^{-1}						
0	473	2.6749	0.0000	0.0155	0.0000	0.1828
5	502	2.7007	0.2000		0.1065	
10	510	2.7076	0.1000		0.1007	
15	506	2.7042	0.0667		0.0472	
Mean					0.0848	
Theoretical maximum yield (A): 514.04 g						
Cu applied kg ha^{-1}						
0	473	2.6749	0.0000	1.1638	0.0000	7.0882
5	521	2.7168	0.3333		0.2092	
10	533	2.7267	0.1667		0.2251	
15	517	2.7135	0.1111		0.0582	
Mean					0.1642	
Theoretical maximum yield (A): 538.80 g						
B applied kg ha^{-1}						
0	481	2.6821	0.0000	1.4276	0.0000	6.6214
2.5	536	2.7292	0.4000		0.3346	
5.0	542	2.7340	0.2000		0.2560	
7.5	521	2.7168	0.1333		0.0562	
Mean					0.2156	
Theoretical maximum yield (A): 545.38 g						

Table 4 : Fertilizer recommendations chart of macronutrients (N, P, K, S, Mg) for *Terminalia tomentosa* based on the Mitscherlich – Bray concept for Ranchi, Jharkhand state

Soil available nutrient	Percent of theoretical yield of leaf biomass		
(kg ha^{-1})	80	85	90
Nitrogen (N)			
50	90	112	142
100	59	81	111
150	29	50	81
200	0	20	50
250	0	0	19
300	0	0	0
Phosphorous (P_2O_5)			
5	36	44	56
10	27	35	46
15	17	25	37
20	7	15	27
25	0	6	17
30	0	0	8
35	0	0	0

Potassium (K_2O)			
50	33	41	52
100	23	31	42
150	14	21	32
200	4	12	22
250	0	2	13
300	0	0	3
350	0	0	0
Sulphur (S)			
2	14	18	23
4	10	14	18
6	6	9	14
8	2	5	10
10	0	1	5
12	0	0	1
14	0	0	0
Magnesium (Mg)			
2	12	15	20
4	6	9	14
6	0	3	7
8	0	0	1
10	0	0	0

Table 5 : Fertilizer recommendations chart of micronutrients (Fe, Zn, Mn, Cu, B) for *Terminalia tomentosa* based on the Mitscherlich – Bray concept for Ranchi, Jharkhand state

Soil available nutrient (mg kg^{-1} of soil)	Percent of theoretical yield of leaf biomass		
	80	**85**	**90**
Iron (Fe)			
10	10	13	17
20	6	9	13
30	2	5	8
40	0	0	4
50	0	0	0
Zinc (Zn)			
0.2	6	7	9
0.4	3	5	7
0.6	0	2	4
0.8	0	1	1
1.0	0	0	0
Manganese (Mn)			
10	6	8	10
20	5	6	8
30	3	4	6
40	1	2	4
50	0	1	3
60	0	0	1
70	0	0	0
Copper (Cu)			
0.2	3	4	5
0.4	1	2	3
0.6	0	1	2
0.8	0	0	0
Boron (B)			
0.1	3	3	4
0.2	2	2	3
0.3	1	2	3
0.4	1	1	2
0.5	0	1	1
0.6	0	0	1
0.7	0	0	0

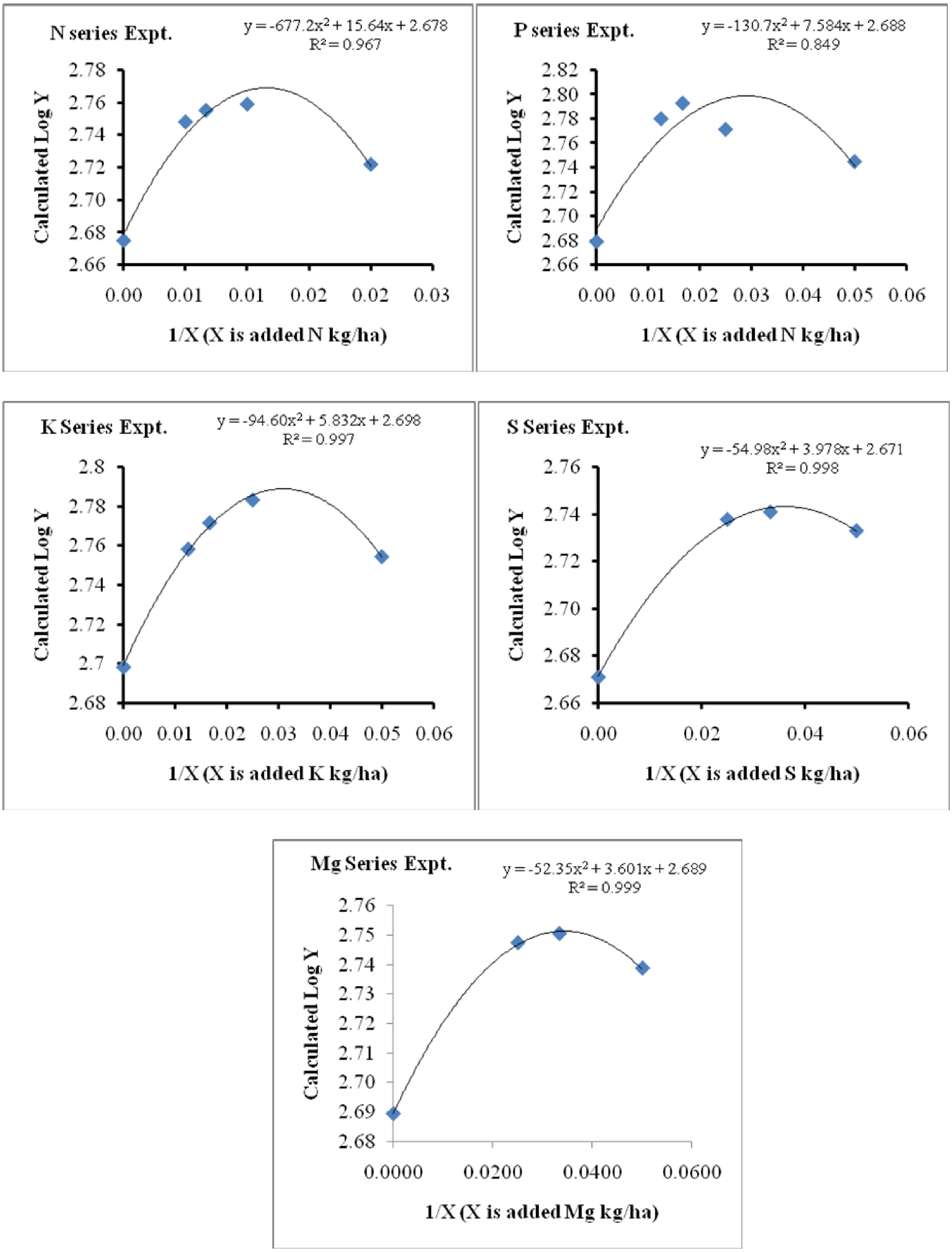

Fig. 1 : Theoretical maximum yield (A) of *Terminalia tomentosa* from the plot of log Y vs. 1/x as affected by levels of macronutrients (N, P, K, S, Mg) application in CTR&TI, Ranchi

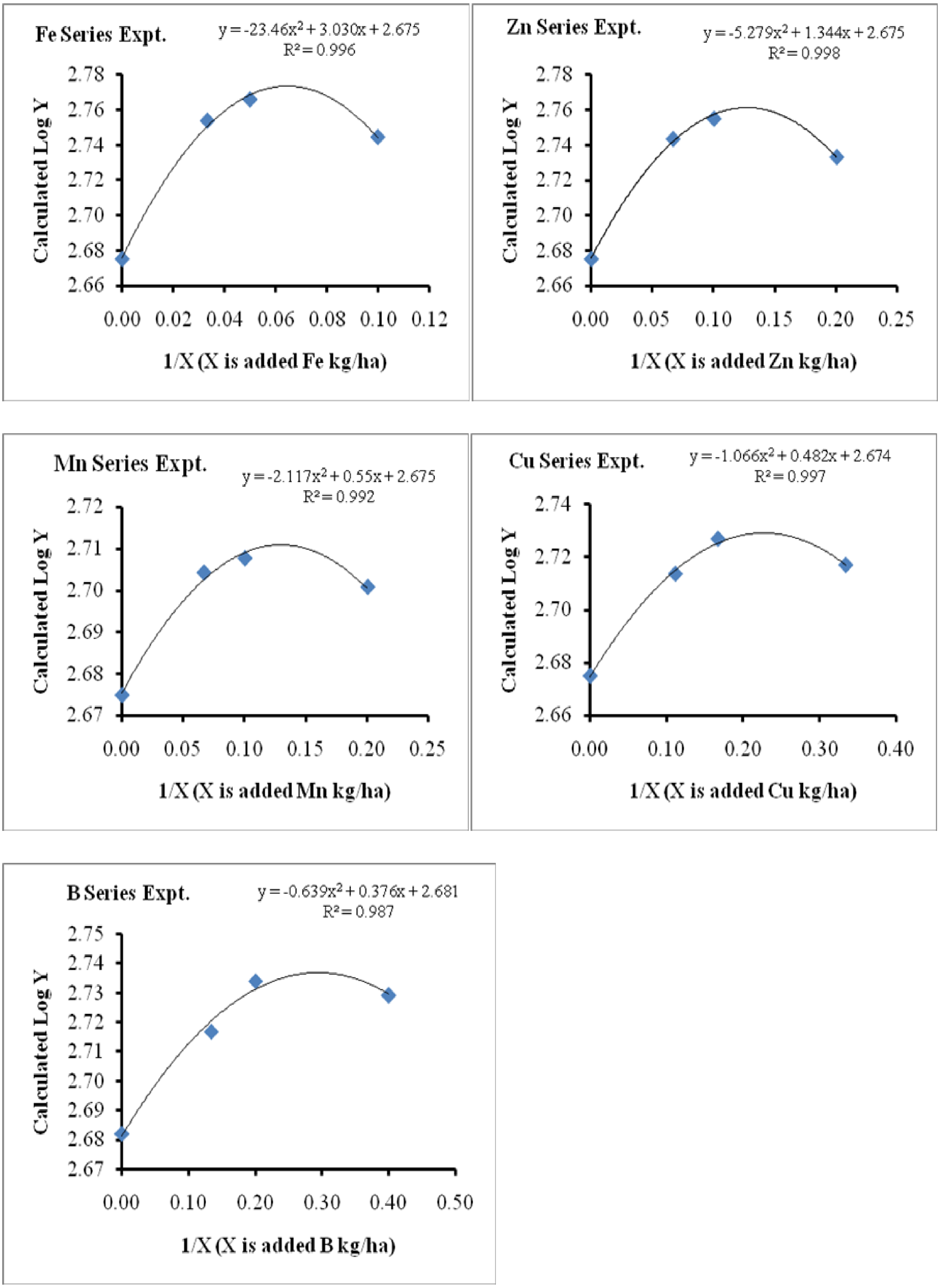

Fig. 4 : Theoretical maximum yield (A) of *Terminalia tomentosa* from the plot of log Y vs. 1/x as affected by levels of micronutrients (Fe, Zn, Mn, Cu, B) applicationin CTR&TI, Ranchi

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