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SOIL TEST BASED NUTRIENT MANAGEMENT FOR *TERMINALIA ARJUNA* UNDER RANCHI CONDITIONS

Susmita Das*, Jitendra Singh, S. Giri[2], Aparna K., Sunil Kumar Misro[3] and N.B. Chawdary

Central Tasar Research & Training Institute, Piska Nagri, Ranchi – 835 303, Jharkhand, India

[2]Regional Tasar Research Station, Dumka, Jharkhand.

[3]Regional Tasar Research Station, Jagdalpur, Chhattisgarh.

*Corresponding Author: sdas1202@gmail.com

ABSTRACT

In tasar culture, generally blanket fertilizer recommendations are followed for N, P & K, often ignoring secondary and micronutrients which rarely matches soil fertility needs. Hence, for effective nutrient management, assessment of nutritional requirement for host plants and fertilizer recommendation should consider crop needs and nutrients already available in the soil. An experiment was conducted at CTRTI, Ranchi's experimental field to determine the optimum nutrient requirement for producing higher leaf biomass yield and quality leaves of Tasar host plant, *Terminalia arjuna* (Arjun). The treatments consisted of different levels of nutrient application for each macronutrient and micronutrient. Soil available nutrients were estimated and leaf yields of Arjun were recorded. The leaf yield of Arjun was found to vary with different doses of applied fertilizers. The study revealed that leaf yield was strongly influenced by applied fertilizers. The data were subjected to Mitscherlich-Bray equation, viz, $log\ (A\text{-}y) = logA\text{-}c_1b\text{-}cx$; where, A-maximum yield possibility when all nutrients are present in adequate amounts but not in excess, 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, c_1- efficiency factor for x. The c1 and c values were calculated for different nutrients. The result indicated that with an increase in soil test values for the different nutrients, there is a corresponding decrease in the nutrient requirements. For example, to achieve the maximum targeted yield as fixed in this study as 90 percent, one has to apply 135, 99, 64 and 28 kg ha^{-1} of N with soil test values of 50, 100, 150 and 200 kg N ha^{-1}, respectively. 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. Fertilizer recommendation chart of macro and micronutrients was prepared for Arjun plants. This chart would be highly helpful for the farmers, stakeholders and others concerned for better nutrient management of *T. arjuna* plants.

Key words: Nutrients, Arjun, Mitscherlich-Bray equation, Fertilizer recommendation, leaf yield.

Introduction

The quantity and quality of silk produced is directly dependent on the leaf quality, which influences the healthy growth of silkworm larvae and thereby affects the cocoon production. Various studies in the past and present on silkworm nutrition have established that it is the quality of leaf that ultimately reflects on growth and development of the silkworm as well as on overall silk production. Nearly 70 per cent of the silk produced by silkworm is directly derived from proteins of leaves. Hence, silkworm should be fed with good quality leaves in abundant quantity for the successful cocoon production. However, continuous exploitation of host plants for silkworm rearing can reduce nutrient reserves of the soil and may affect plant growth and productivity. In the long run it may result in decrease of crop yield and soil fertility. Hence, nutrient management is essential for proper growth of plants and consequently the good cocoon crop.

Effective nutrient management involves meeting the nutrient requirements for expected yield from the nutrient reserves in soil and additional supplementation of nutrients by chemical fertilizers and organic manures. Thus nutrient management consists of two steps – a) to assess the nutrient requirement of the crops to be grown. – b) to increase the nutrient reserves of the soil and its availability to the plants by supplementation of nutrients through fertilizers and manures. Maintaining nutritional balance not only facilitates high yields but also reduces the need for utilization of extra land.

The conventional fertilizing method is not scientifically appropriate and efficient because soil fertility varies between regions. Overuse of fertilizers can indeed lead to a waste of fertilizer and a serious environmental pollution. In India, generally blanket fertilizer recommendations are followed for N, P & K that rarely matches soil fertility need and often ignoring secondary and micronutrients. All these factors result in deterioration in soil quality/ soil health with adverse consequences for sustaining high levels of productivity. In this regard, application of optimum dose of nutrients is one of the important inputs for increasing leaf yield.

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). Also, the chemical fertilizers are becoming costlier day by day due to escalating costs and scarce availability of commodities. Further, intensive cropping system causes depletion of nutrients in soil and excess use of inorganic fertilizers and pesticides caused deleterious effect on soil health (Shashidhar *et al*., 2009).

To enhance productivity and profitability under different soil-climate conditions, it is necessary to have information on optimum fertilizer doses for crops. Hence, refinement and optimization of nutritional requirement for quality cocoon production is crucial for present situations. Therefore, the study of nutrients requirements for host plants is pursued and a fertilizer recommendation chart has been developed for better nutrient management of *T. arjuna* plants.

Materials and Methods

Experiment was conducted at block plantation field of *Terminalia arjuna* at CTR & TI, Ranchi Jharkhand to determine the optimum nutrient requirement for producing higher leaf biomass yield and quality leaves of Tasar host plants. *Terminalia arjuna* (Arjun) was selected as a test plant in the experiment. The treatments consisted of different levels of nutrient application for each macronutrient and micronutrient. The host plants were given different fertilizer treatments as mentioned in nutrient treatments series given below along with FYM @ 12.5 mt ha^{-1} year^{-1}.

Table 1: Treatment details of Macronutrients and Micronutrients

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					

The actual leaf yield of Arjuna was recorded. The biomass yield were subjected to **Mitscherlich-Bray equation**, viz., $\log (A-y) = \log A - c_1 b - cx$ 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, c_1- efficiency factor for x (Bray, 1949). After finding the c_1 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, amount of nutrient already present in the soil and the fertilizers added, 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 a Ready reckoner for individual nutrients has been developed for getting targeted yield of tasar host plants for the common range of soil test values of available nutrient contents.

Composite soil samples were collected (0-30 cm.) before initiating and post harvest treatment. The soil samples were air dried and passed through 2 mm sieve and used for analysis of nutrients. The laboratory analysis was done according to methods given as below.

Methods adopted for soil testing

Soil characteristics	Method
pH	1: 2.5 soil water suspension (Jackson, 1973)
EC (dS/m)	1: 2.5 soil water suspension (Jackson, 1973)
Soil Moisture %	Gravimetric method (Hesse,2002)
Organic Carbon %	Walkley and Black (1934)
Available N	Alkaline $KMnO_4$ method (Subhiah& Asija, 1956)
Available P	Bray and Kruz (1945)/ Olsen method
Available K	Ammonium acetate extracts (using flame photometer).
Available S	Turbidity method (Chesnin and Yien, 1951)
Available Mg	EDTA titration method (Cheng and Bray 1951)
Available Fe, Cu, Zn & Mn	DTPA extractable, Lindsay and Norvell (1978) (Using Atomic Absorption Spectrometer)
Available B	Hot water soluble B method.

Results and Discussion

The actual leaf yield of Arjun i.e., weight of leaves under different doses of macronutrients applied in the site was recorded and given in Table 2 & 3. Table 2 & 3 shows that leaf yield of Arjun plant has considerably increased with an increased dose of fertilizer and percentage of increase in leaf yield was decreased at each next higher dose of fertilizers. In all the cases, the leaf yield was positively increased up to a certain level, thereafter, the yield has decreased. For instance, the leaf yield was increased with the N dose up to 150 kg ha^{-1} and the yield was decreased thereafter. The same trend was true in the case of all the nutrients during the study period. Sinha *et al.* (1999) conducted field trial experiment with different combination of NPK on *T. arjuna* tree. They concluded that nutrients supplied in combination of 150-50-50 kg NPK per hectare recorded significantly superior in terms of foliage yield and ERR.

Similarly, increase in leaf yield in case of micronutrients was observed which might be due to their role in various physiological processes and favourable effects on nutrient interaction. Similar trend of increased leaf yield by the application of micronutrients has been reported by Day and Gupta (1974) and Bose *et al.* (1994). Results of the experiments of Loknath and Shivshankar (1986) revealed that deficiencies of micronutrients limit the maximum potential yield of mulberry. Sinha *et al.* (2006) studied the effect of individual micronutrient on the growth and leaf yield of *Terminalia arjuna*. Studies made by Satish *et al.* (2011) and Tadesse *et al.* (2012) on conjunctive use of organic and inorganic nutrient sources in rice has successfully demonstrated improvement in soil physical and chemical properties and crop productivity. Rajanna *et al.* (2000) reported that, the application of recommended FYM+NPK recorded significantly higher macro nutrients in mulberry leaf followed by sheep manure + recommended FYM.

The nutrient requirements were decided by using Mitscherlich–Bray equation. 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. The Mitscherlich equation is a useful tool for such a purpose.

Using the equation, the theoretical maximum yield was found for different nutrient applications obtained from the plot of log y against 1/x (Fig. 1&2). The c1 and c values were calculated for different nutrient applications. Among the macronutrients, the c1 value for K was smaller as compared to the c1 values of N, P, S and Mg which mean that soil K was less efficiently utilized by the Arjun plant compared to the soil N, P, S and Mg (Table 3). The higher c1 value was found with P followed by Mg and K. The ratio c1/c indicates the response of Arjun 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 in the experiment was the lowest as compared to the c1/c ratio values of N, P, S and Mg experiments, indicating that Arjun 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 Fe experiment was the lowest of other nutrients followed by Mn and Zn. The B was found to be a higher ratio of c1/c in this experiment (Table 4).

The findings of this study suggest that soil test alone is not a reliable basis for formulating fertilizer recommendations. From the experiment it was indicated that even if the sufficient amounts of nutrients are present in the soil, it was capable of producing only 50-70 percent of the maximum possible yield. The study suggests that even if the soil has sufficient amounts of nutrients present in it, fertilization is still found necessary for higher leaf biomass yield.

Table 4&5 shows the fertilizer recommendations derived from the leaf yield data of different treatments 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 84, 33 and 32 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. For achieving the maximum targeted yield as fixed in this study as 90 percent, one has to apply 135, 99, 64 and 28 kg ha^{-1} with soil test values of 50, 100, 150 and 200 kg 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 (Table 4 & 5).

Conclusion

The existing practice of using "blanket fertilizer application" 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.

It is worthwhile to enhance the fertilizer use efficiency and economize its use for sustainable Tasar silk production. To achieve high percentage relative yields, the Mitscherlich-Bray 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 arjuna* 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	265	2.423	0.0000	0.00416	0.0000	0.7082
50	291	2.464	0.0200		0.0045	
100	316	2.500	0.0100		0.0068	
150	326	2.513	0.0067		0.0084	
200	319	2.504	0.0050		0.0039	
Mean					0.0059	
Theoretical maximum yield (A): 329.61 g						
P_2O_5 applied kg ha^{-1}						
0	271	2.433	0.0000	0.0424	0.0000	2.8748
20	297	2.473	0.0500		0.0142	
40	319	2.504	0.0250		0.0237	
60	317	2.501	0.0167		0.0138	
80	311	2.493	0.0125		0.0073	
Mean					0.0147	
Theoretical maximum yield (A): 325.09 g						
K_2O applied kg ha^{-1}						
0	238	2.3766	0.0000	0.00246	0.0000	0.1385
20	290	2.4624	0.0500		0.0312	

40	300	2.4771	0.0250		0.0261	
60	288	2.4594	0.0167		0.0096	
80	275	2.4393	0.0125		0.0042	
Mean					0.0178	
Theoretical maximum yield (A): 306.19 g						
Sulphur applied kg ha^{-1}						
0	161	2.2068	0.0000	0.04144	0.0000	1.0510
20	243	2.3856	0.0500		0.0325	
30	265	2.4232	0.0333		0.0599	
40	257	2.4099	0.0250		0.0259	
Mean					0.0394	
Theoretical maximum yield (A): 266.69 g						
Magnesium applied kg ha^{-1}						
0	187	0.000	2.2718	0.06787	0.0000	1.7520
20	247	0.050	2.3927		0.0314	
30	264	0.033	2.4216		0.0577	
40	259	0.025	2.4133		0.0271	
Mean					0.0387	
Theoretical maximum yield (A): 265.46 g						

Table 3: Leaf yields of *Terminalia arjuna* 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	219	2.3404	0.0000	0.021928	0.0000	0.3314
10	283	2.4518	0.1000		0.1655	
20	267	2.4265	0.0500		0.0287	
30	236	2.3729	0.0333		0.0044	
Mean					0.0662	
Theoretical maximum yield (A): 284.45 g						
Zn applied kg ha^{-1}						
0	125	2.0969	0.0000	0.7897	0.0000	8.7401
5	148	2.1703	0.2000		0.0837	
10	161	2.2068	0.1000		0.1498	
15	152	2.1818	0.0667		0.0375	
Mean					0.0904	
Theoretical maximum yield (A): 162.18 g						
Mn applied kg ha^{-1}						
0	115	2.0607	0.0000	0.009771	0.0000	0.1238
5	140	2.1461	0.2000		0.0897	
10	150	2.1761	0.1000		0.1007	
15	146	2.1644	0.0667		0.0464	
Mean					0.0789	
Theoretical maximum yield (A): 153.82 g						
Cu applied kg ha^{-1}						
0	196	2.2923	0.0000	0.832649	0.0000	10.5922
5	224	2.3502	0.2000		0.0766	
10	240	2.3802	0.1000		0.1102	
15	235	2.3711	0.0667		0.0491	
Mean					0.0786	
Theoretical maximum yield (A): 243.78 g						
B applied kg ha^{-1}						
0	211	2.3243	0.0000	1.909262	0.0000	11.1529
2.5	225	2.3522	0.4000		0.2161	
5	229	2.3598	0.2000		0.2142	
7.5	226	2.3541	0.1333		0.0833	
Mean					0.1712	
Theoretical maximum yield (A): 230.67 g						

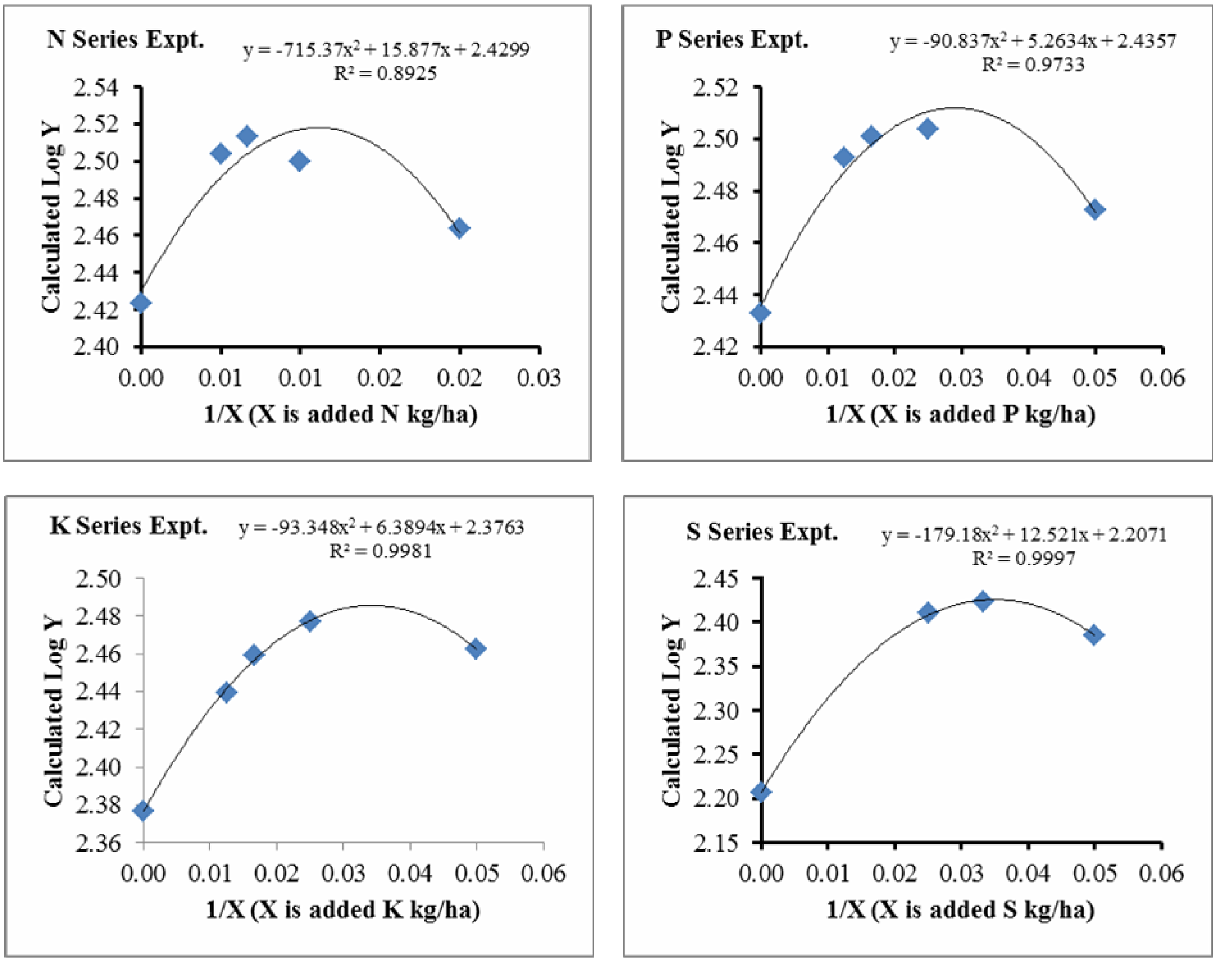

Fig. 1 : Theoretical maximum yield (A) of *Terminalia arjuna* from the plot of log Y vs. 1/x as affected by levels of macronutrients (N, P, K, S, Mg) application in CTR&TI, Ranchi

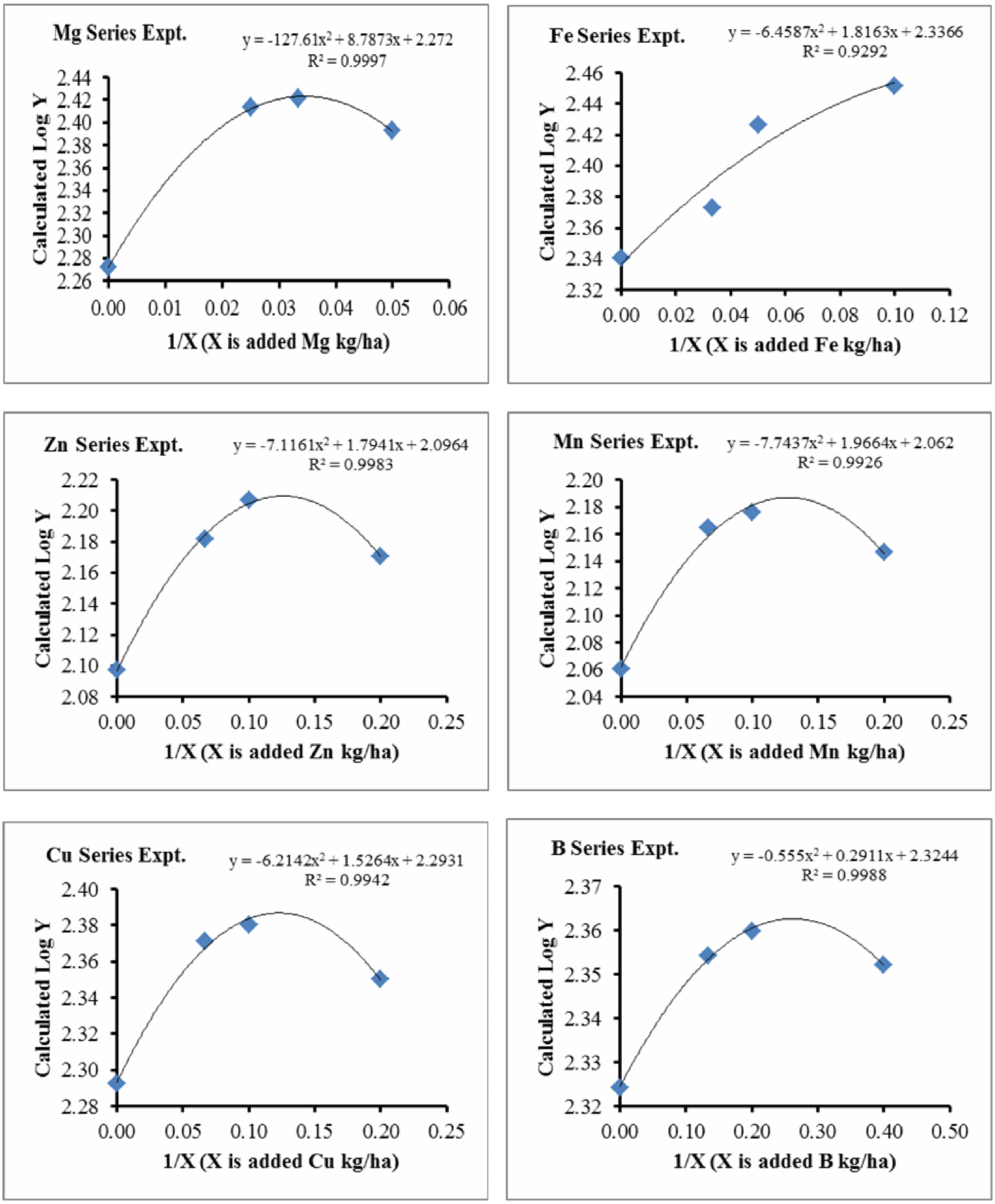

Fig. 2 : Theoretical maximum yield (A) of *Terminalia arjuna* from the plot of log Y vs. 1/x as affected by levels of micronutrients (Fe, Zn, Mn, Cu, B) application CTR&TI, Ranchi

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

Soil available nutrient (kg ha^{-1})	Percent of theoretical yield of leaf biomass		
	80	85	90
Nitrogen (N)			
50	84	105	135
100	48	69	99
150	13	34	64
200	0	0	28
250	0	0	0
Phosphorous (P_2O_5)			
5	33	41	53
10	19	27	39
15	4	13	25
20	0	0	10
25	0	0	0
Potassium (K_2O)			
50	32	39	49
100	25	33	42
150	19	26	35
200	12	19	29
250	5	12	22
300	0	5	15
350	0	0	8
400	0	0	1
450	0	0	0
Sulphur (S)			
3	15	18	22
6	11	15	19
9	8	11	16
12	5	8	13
15	2	5	10
18	0	2	6
21	0	0	0
Magnesium (Mg)			
3	13	16	21
6	8	11	15
9	2	6	10
12	0	0.25	5
15	0	0	0

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

Soil available nutrient (mg kg^{-1}of soil)	Percent of theoretical yield of leaf biomass		
	80	85	90
Iron (Fe)			
10	7	9	12
20	4	6	8
30	1	3	5
40	0	0	2
50	0	0	0
Zinc (Zn)			
0.2	12	15	15
0.4	8	11	12
0.6	5	8	8
0.8	1	4	5
1.0	0	1	1
1.2	0	0	0
Manganese (Mn)			
0.3	7	8	10
0.6	4	6	8
0.9	2	4	6
1.2	0	1	4
1.5	0	0	1
1.8	0	0	0
Copper (Cu)			
0.2	7	8	11
0.4	5	6	8
0.6	3	4	6
0.8	0	2	4
1.0	0	0	2
1.2	0	0	0
Boron (B)			
0.1	3	4	5
0.2	2	3	4
0.3	1	1	2
0.4	0	0	1
0.5	0	0	0

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