Correlation and Regression of Growth and Yield Attributes and Yield of Transplanted Rice as Affected by Weed Management Practices

.

ABSTRACT

Rice (*Oryza sativa* L.) is a major staple crop influenced by the interaction of growth traits, nutrient dynamics, and weed competition. A field experiment was conducted during the *rabi* season of 2025–26 at Karunya Institute of Technology and Sciences, Coimbatore, to evaluate the relationship between grain yield, growth parameters, nutrient uptake, and weed interference. The experiment was laid out in a randomized block design with ten treatments and three replications. Correlation and regression analyses were performed to identify key yield-determining factors.

The results revealed that grain yield had highly significant positive correlations with stover yield, plant height, leaf area index, dry matter production, productive tillers, test weight, and nutrient uptake (N, P, and K), indicating that enhanced biomass production and efficient nutrient assimilation are critical for yield improvement. Among these, dry matter production and phosphorus uptake emerged as the most influential factors governing yield variation. In contrast, weed density, weed dry weight, and nutrient removal by weeds showed strong negative associations with grain yield, highlighting the adverse effects of weed competition on crop growth and resource utilization.

Regression analysis further confirmed that yield increased with improvements in growth and nutrient parameters, while it declined significantly under higher weed infestation. The study emphasizes that effective weed management combined with balanced nutrient application is essential for optimizing resource use efficiency, maintaining favorable source–sink relationships and achieving higher rice productivity.

Keywords: Rice, Grain yield, Correlation analysis, Regression analysis, Dry matter production, Nutrient uptake, weed density, weed management, source–sink relationship, Productivity

1. INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important staple crops in the world, providing a major source of dietary energy and essential nutrients for more than half of the global population, particularly in Asia, Africa, and Latin America [1]. It plays a vital role in ensuring food security and sustaining rural livelihoods in major rice-growing countries such as India, China, Bangladesh, Indonesia, Pakistan, and Afghanistan, while also contributing significantly to national economies through production and trade [2,3].

Grain yield in rice is a complex trait determined by the interaction of physiological, morphological, and genetic factors that regulate source–sink relationships. Key traits such as leaf area index, tiller number, chlorophyll content, biomass accumulation, and panicle characteristics collectively influence photosynthetic efficiency and assimilate production [4,5]. The dry matter produced through photosynthesis is partitioned into grains through efficient assimilate transport, which ultimately determines final yield. In addition, balanced nutrient management, particularly the application of nitrogen, phosphorus, and potassium, enhances vegetative growth, enzymatic activity, and grain filling, thereby improving overall productivity [6–8].

However, rice productivity is severely constrained by weed infestation, which competes with the crop for essential resources such as nutrients, water, and light. Weed interference during early growth stages is particularly harmful, as it reduces crop establishment, nutrient uptake, and biomass accumulation, ultimately leading to significant yield losses [9,10]. Higher weed density and biomass further intensify this competition, making effective weed management a critical component of rice production systems. Integrated weed management practices are therefore essential to minimize weed pressure and improve nutrient use efficiency and crop performance.

Although considerable research has been conducted on yield prediction, nutrient management, and weed control in rice, most studies have treated these components separately. Limited attention has been given to their integrated effects on crop performance and yield formation. Correlation analysis is useful for identifying the most influential yield-contributing traits, while regression analysis enables quantitative prediction of yield based on interacting agronomic variables [11,12]. Therefore, integrating growth traits, nutrient dynamics, and weed effects is essential for developing more accurate yield prediction models and improving agronomic decision-making.

2. MATERIALS AND METHODS

2.1 Study area location

The experiments was conducted in South Farm, School of Agricultural Sciences, Division of Agronomy, Karunya Institute of Technology and Sciences, Coimbatore, during the *rabi* season of 2025-26 (August 2025-January 2026). The farm is geographically situated in the North Western Agro-Climatic Zone of Tamil Nadu at 10°55'57.5"°N latitude, 76°45'02.2" E longitude and at an altitude of 516.97 m above mean sea level. During the cropping period, the experimental site experienced typical semi-arid tropical climatic conditions with moderately high temperature, moderate rainfall and favourable sunshine hours. The prevailing weather conditions were suitable for normal growth and development of the rice crop. Prior to the initiation of the experiment, the soil samples were collected randomly from 0 to 15 cm depth from 5 spots of the experimental field. All of these soil samples were combined to create a representative homogenous composite sample, which was then examined to ascertain the mechanical and physio-chemical characteristics of the soil. The soil was Silty clay loam in texture, 0.79 % in organic carbon and 278.1 kg ha^{-1} in available nitrogen, 37.5 kg ha^{-1} in phosphorus and 337 kg ha^{-1} in potassium.

2.2 Experimental details

Field experiments were laid out in Randomized block design and treatments were replicated thrice. The treatments consisted of T_1 PE application of Butachlor 50 EC @ 1.5 kg a.i / ha on 3 DAT *fb* PoE application of 2,4 D @ 1.25 kg a.i / ha on 3 weeks after transplanting,T_2 PE application of Pretilachor (Soil Application) 50 EC @ 1 kg a.i / ha on 3 DAT *fb* PoE application of 2,4 D @ 1.25 kg a.i / ha on 3 weeks after transplanting, T_3 PE application of Pretilachlor (Foliar Application) 50 EC @ 1 kg a.i / ha on 3 DAT *fb* PoE application of 2,4 D @ 1.25 kg a.i / ha on 3 weeks after transplanting, T_4 PoE application of Bispyribac Sodium 10 SC @ 25 ml / ha on 20 - 25 DAT, T_5 PoE application of Triafamone 20 % + Ethoxysulfuron 10% WG @ 66.5 g / ha on 18 - 23 DAT, T_6 PoE application of Bensulfuron methyl 0.6 % + Pretilachor 6% GR @ 660 g / ha on 18 - 23 DAT, T_7 PoE application of Florpyrauxifen-benzyl 2.13 % W/W + Cyhalofop-butyl 10.64 % W/W EC (RM) @ 150 g / ha on 18 - 23 DAT, T_8 Weed free up to harvest, T_9 Farmers Practice (One hand weeding on 20 DAT and other on 35 DAT), T_{10} Control. Herbicides were applied using a knapsack sprayer fitted with a flat-fan nozzle with a spray volume of 600 L ha.

2.3 Statistical analysis

To evaluate the relationship, correlation, and regression coefficients between the grain yield of (*Oryza sativa L.*) (Y) and independent variables (X) including weed density, weed dry matter, crop dry matter accumulation, yield attributes, nutrient depletion by weeds, and nutrient uptake by the crop using the method describer by Snedecor and Cochran [25]. Additionally, simple linear regression equations which was given by Panse and Sukhatme [26] were calculated for the various growth parameters, yield attributes, yield, and nutrient uptake. The correlation studies were done by analyzing in SPSS tool is a widely used software tool for statistical analysis in various fields, including social sciences, business, healthcare, and agriculture. Developed by IBM, SPSS provides a range of features and functions to assist researchers and analysts in data management, exploration, and statistical modeling.

3. RESULTS AND DISCUSSION

The results revealed that grain yield exhibited highly significant positive correlations with stover yield (0.979**), plant height (0.968**), leaf area index (0.889**), dry matter production (0.995**), productive tillers (0.961**), test weight (0.768**) and nutrient uptake parameters including nitrogen (0.977**), phosphorus (0.990**) and potassium (0.954**). These relationships indicate that grain yield is primarily a function of coordinated improvements in vegetative growth, assimilate production and nutrient acquisition. The exceptionally strong association with dry matter production (0.995**) highlights the central role of biomass accumulation as the primary source of assimilates for grain filling. Physiologically, higher leaf area index enhances radiation interception and photosynthetic efficiency, thereby increasing carbohydrate production and strengthening source activity, which ultimately supports sink demand during reproductive development [4,13].

The positive association of grain yield with productive tillers and test weight further reflects enhanced sink strength and reproductive efficiency. Increased productive tillers directly determine panicle density, while higher test weight indicates improved grain filling due to efficient translocation of assimilates and enhanced starch biosynthesis. This reflects improved phloem transport efficiency and stronger source–sink connectivity during the grain filling period [14,15]. Similar patterns were also reported by [16,17], confirming the consistency of growth–yield relationships across environments.

A strong and consistent positive interrelationship among growth traits was observed, where plant height was significantly associated with leaf area index (0.932**), dry matter production (0.974**) and productive tillers (0.983**). Likewise, stover yield showed similar associations with these traits. This indicates that improved canopy architecture enhances radiation use efficiency and promotes greater biomass partitioning. A taller and well-developed canopy increases light interception while improving internal shading balance, leading to higher photosynthetic efficiency and overall biomass production. Additionally, such canopy structure improves competitive ability against weeds by reducing light availability at the soil surface [18].

In contrast, weed parameters exerted strong negative effects on crop performance. Grain yield declined significantly with increasing weed density (-0.846**) and weed dry weight (-0.860**), while similar reductions were observed in stover yield and plant height. This clearly demonstrates that weeds impose strong interspecific competition, particularly during early vegetative stages, when crops are most sensitive to resource limitation. Weeds with rapid early growth and higher nutrient acquisition efficiency reduce the availability of essential resources, thereby suppressing crop photosynthesis, growth rate and biomass accumulation [19].

The strong positive correlation between weed density and weed dry weight (0.997**) indicates that greater weed population directly translates into higher biomass accumulation, intensifying competitive pressure on the crop. Furthermore, weed density exhibited strong positive correlations with nutrient removal (N: 0.948**, P: 0.920**, K: 0.923**), confirming that weeds act as aggressive nutrient sinks. This results in depletion of soil nutrient reserves and reduced nutrient availability for the crop, thereby limiting chlorophyll synthesis, energy metabolism and assimilate production. This mechanism explains the observed negative relationship between grain yield and nutrient removal (N: -0.922**, P: -0.817**, K: -0.818**) [20].

Weed control efficiency showed a strong positive association with grain yield (0.846**) and productive tillers (0.934**), and a perfect negative association with weed density (-1.000**) and weed dry weight (-0.997**). This indicates that effective weed management significantly reduces interspecific competition, allowing crops to utilize available resources more efficiently. Agronomically, timely and integrated weed management ensures that the crop remains free from early-season competition, which is critical for establishing yield potential [21].

Nutrient uptake parameters (N, P and K) were strongly interrelated and positively associated with growth and yield attributes, indicating the importance of balanced nutrient availability in sustaining physiological processes. Nitrogen enhances chlorophyll content and photosynthetic rate, phosphorus plays a key role in ATP synthesis and root development, and potassium regulates enzyme activation and stomatal conductance. Together, these nutrients optimize metabolic activity, improve assimilate production and enhance grain filling efficiency [22]. In contrast, nutrient removal by weeds directly reduces nutrient use efficiency and weakens crop physiological performance.

Regression analysis further reinforced these relationships, showing that grain yield increased with stover yield (R^2 = 0.959), plant height (R^2 = 0.937), dry matter production (R^2 = 0.990), productive tillers (R^2 = 0.924), nitrogen uptake (R^2 = 0.954), phosphorus uptake (R^2 = 0.980) and potassium uptake (R^2 = 0.911). Among these, dry matter production and phosphorus uptake emerged as the most influential determinants of yield variation, indicating their critical role in assimilate supply and energy metabolism during reproductive development [7,23].

Conversely, grain yield declined with increasing weed density (R^2 = 0.716), weed dry weight (R^2 = 0.739) and nutrient removal (R^2 = 0.667–0.851), confirming the strong suppressive effect of weed interference on crop productivity. Severe weed infestation disrupts source–sink balance, reduces nutrient availability and limits photosynthetic efficiency, ultimately resulting in yield reduction [24].

4. CONCLUSION

Grain yield showed strong positive correlations with plant height, leaf area index, dry matter production, productive tillers and NPK uptake, indicating that higher biomass production and efficient nutrient assimilation drive yield formation. Regression analysis further confirmed that grain yield increases with improvements in growth traits and nutrient uptake, highlighting their strong predictive value. In contrast, weed density and weed biomass showed significant negative correlations with all crop growth and yield parameters, reflecting severe competition for light, nutrients and moisture. Regression results also indicated a clear decline in grain yield with increasing weed pressure and nutrient removal by weeds. Overall, the study emphasizes that effective weed management and balanced nutrition are critical to minimize competition and maximize grain yield.

REFERENCES

1. Mohidem NA, Hashim N, Shamsudin R, Man HC. Rice for Food Security : Revisiting Its Production , Diversity , Rice Milling Process and Nutrient Content. 2022.
2. Salihi MS, Yaqoobi KA, Irfan H. Role of Rice in Food Security of Afghanistan : A Review. 2025;3: 264–275.
3. Aleen MJ, Datta T. Productivity of Food and Self-Sufficiency in Rice Production in Bangladesh. 2025;12: 214–226. doi:10.17265/2328-7144/2025.03.003
4. Vishwakarma AK, Prakash B, Id M, Das H, Jha P. Impact of sequential herbicides application on crop productivity , weed and nutrient dynamics in soybean under conservation agriculture in Vertisols of Central India. 2023; 1–19. doi:10.1371/journal.pone.0279434

5. Wu X, Xie D, Xu A, Yuan P, Huang J, Jiang L, et al. Interactive effects of seedling number per hill and plant spacing on source-sink dynamics and yield formation in rice. 2025; 1–17. doi:10.3389/fpls.2025.1707882

6. Hu Z, Liu K, Xu X, Hu D, Song H, Wu Y, et al. Photosynthesis and senescence gene expression drive yield improvements in early season rice under long-term method of fertilization. 2025; 1–12.

7. Yield R, Zhou S, Liu K, Zhuo X, Wang W, Zhang W, et al. Optimizing Nitrogen Regime Improves Dry Matter and Nitrogen Accumulation during Grain Filling to Increase. 2023.

8. Shankar T, Malik GC, Banerjee M, Dutta S, Praharaj S, Lalichetti S, et al. Prediction of the Effect of Nutrients on Plant Parameters of Rice by Artificial Neural Network. 2022.

9. Kanjibhai A, Korav S, Rajanna GA, Elansary HO, Mahmoud EA. Heliyon Determination of critical crop-weed competition period : Impact on growth , nutrient dynamics and productivity of green gram (Vigna radiata). Heliyon. 2024;10: e36855. doi:10.1016/j.heliyon.2024.e36855

10. Kumar A. " Agricultural Weeder with Nail Assembly " for Weed Control , Soil Moisture Conservation , Soil Aeration and Increasing Crop Productivity. 2022;12: 3056–3068. doi:10.9734/IJECC/2022/v12i111351

11. Gupta I, Ayalasomayajula S, Shashidhara Y, Kataria A, Shashidhara S. Innovations in Agricultural Forecasting : A Multivariate Regression Study on Global Crop Yield Prediction. 2019.

12. Morshed S, Barua F, Khanom A, Lokman F, Zubair HT. Smart Agricultural Technology Crop yield prediction using machine learning : An extensive and systematic literature review. Smart Agric Technol. 2025;10: 100718. doi:10.1016/j.atech.2024.100718

13. Cheng F, Bin S, Iqbal A, He L, Wei S, Zheng H, et al. High Sink Capacity Improves Rice Grain Yield by Promoting Nitrogen and Dry Matter Accumulation. 2022; 1–16.

14. Deng R, Zheng D, Feng N, Khan A, Zhang J, Sun Z. Prohexadione Calcium Improves Rice Yield Under Salt Stress by Regulating Source – Sink Relationships During the Filling Period. 2025.

15. Wang S, Wang Y, Chen Z. Large Vascular Bundle Phloem Area 4 enhances grain yield and quality in rice via source – sink – flow. 2023; 317–334.

16. Fei D, Lian-hua HE, Duo C, Chi Z, Qing-lan T, Zhen-yuan WU, et al. Growth characteristics and grain yield of machine-transplanted medium indica hybrid rice with high daily yield. J Integr Agric. 2022;21: 2547–2558. doi:10.1016/j.jia.2022.07.030

17. Poudel A, Singh M, Dhami C, Adhikari A, Shrestha J. Detection of superior rice genotypes through evaluating growth and yield parameters. 2023;15: 66–74.

18. Tian P, Liu J, Zhao Y, Huang Y, Lian Y, Wang Y, et al. Nitrogen rates and plant density interactions enhance radiation interception , yield , and nitrogen use efficiencies of maize. 2022. doi:10.3389/fpls.2022.974714

19. Kumar S, Chattopdhayaya N. Weed Control by New Generation Herbicide and Its Influence on Yield and Nutrient Uptake in Transplanted Rice. 2023;35: 994–1002. doi:10.9734/IJPSS/2023/v35i214070

20. Wickramasinghe D, Devasinghe U. Weed dynamics under diverse nutrient management and crop rotation practices in the dry zone of Sri Lanka. 2023; 1–15. doi:10.3389/fagro.2023.1211755

21. Nayak JK, Satapathy M, Behera B, Dwibedi SK, Panda RK. e - Publishing Group Interactive effect of nutrient and weed management in transplanted rice (Oryza sativa L .) for enhancing the productivity in Eastern India. 2024;11: 1034–1046.

22. Shehzadi N, Mahmood A, Kaleem M, Chishti MS, Bashir H, Hashem A, et al. Zinc and nitrogen mediate the regulation of growth , leading to the upregulation of antioxidant aptitude , physio -

biochemical traits , and yield in wheat plants. Sci Rep. 2024; 1–15. doi:10.1038/s41598-024-63423-y

23. Fu Y, Lu C, Zhong X, Liang K, Pan J, Liu Y, et al. transport and nutrient uptake differentiate hybrid and inbred indica rice in the double- cropping system in South China. 2024; 1–12. doi:10.3389/fpls.2024.1433402

24. Agric AJ, Article O. Assessing critical period of weed competition in direct seeded rice (Oryza sativa L.). 2023;2023: 1–13. doi:10.35495/ajab.2022.190

25. Snedecor GW, Cochran WG. Statistical Methods. Oxford and IBH Pub. Co., New Delhi; 1968

26. Panse VG, Sukhatme PV. Statistical methods for agricultural workers. Indian Council of Agricultural Research, New Delhi; 1985.

Table 1. Correlation coefficient between weed attributes, growth, yield components and yield of transplanted rice

S.No	Parameters	GY	SY	PH	LAI	DMP	PT	TW	WD	WDW	WCE	NU	PU	KU	NR	PR	KR
1	GY	1															
2	SY	.979**	1														
3	PH	.968**	.966**	1													
4	LAI	.889**	.837**	.932**	1												
5	DMP	.995**	.994**	.974**	.875**	1											
6	PT	.961**	.937**	.983**	.946**	.956**	1										
7	TW	.768**	.755*	.828**	.890**	.775**	.852**	1									
8	WD	-.846**	-.822**	-.886**	-.881**	-.837**	-.934**	-.780**	1								
9	WDW	-.860**	-.841**	-.902**	-.896**	-.854**	-.945**	-.801**	.997**	1							
10	WCE	.846**	.822**	.886**	.881**	.837**	.934**	.779**	-1.000**	-.997**	1						
11	NU	.977**	.948**	.979**	.928**	.970**	.978**	.806**	-.851**	-.867**	.851**	1					
12	PU	.990**	.986**	.986**	.905**	.995**	.965**	.794**	-.846**	-.862**	.846**	.980**	1				
13	KU	.954**	.961**	.979**	.873**	.964**	.967**	.807**	-.844**	-.860**	.844**	.977**	.970**	1			
14	NR	-.922**	-.903**	-.956**	-.912**	-.919**	-.980**	-.802**	.948**	.956**	-.948**	-.955**	-.929**	-.953**	1		
15	PR	-.817**	-.785**	-.893**	-.939**	-.812**	-.926**	-.883**	.920**	.933**	-.920**	-.874**	-.834**	-.860**	.941**	1	
16	KR	-.818**	-.789**	-.894**	-.931**	-.814**	-.930**	-.884**	.923**	.935**	-.923**	-.878**	-.834**	-.869**	.948**	.999**	1

** – Significant at 1%; * – Significant at 5%

Note:
GY (Grain yield), SY (Stover yield), PH (Plant height), LAI (Leaf Area Index), DMP (Dry matter production), PT (Number of productive tillers), TW (Test weight), WD (Weed density), WDW (Weed dry weight), WCE (Weed control efficiency), NU (Nitrogen uptake), PU (Phosphorus uptake), KU (Potassium uptake), NR (Nitrogen removal by weeds), PR (Phosphorus removal by weeds), and KR (Potassium removal by weeds). $P < 0.05$ and **P** < 0.01 indicate the probability levels of significance for Pearson's correlation coefficients (two-tailed).

Table 2. Regression coefficients (b values) and intercept (a) of different component traits on grain yield of transplanted rice along with their coefficient of determination (R2)

Character	Intercept (a)	Regression coefficient (b)	R^2	Regression equation (Y = a+bx)
Straw	-8.39	1.5156	0.959	$Y = -8.39 + 1.5156X_1$
Plant height	62.01	0.012	0.937	$Y = 62.01 + 0.0120X_2$
DMP	438.39	2.4123	0.99	$Y = 438.39 + 2.4123X_3$
LAI	-0.97	0.0009	0.79	$Y = -0.97 + 0.0009X_4$
Test weight	20.17	0.0003	0.589	$Y = 20.17 + 0.0003X_5$
Productive tillers	-4.4	0.0035	0.924	$Y = -4.40 + 0.0035X_6$
Weed density	102.16	-0.0156	0.716	$Y = 102.16 - 0.0156X_7$
Weed dry weight	104.56	-0.0161	0.739	$Y = 104.56 - 0.0161X_8$
WCE	-70.55	0.026	0.716	$Y = -70.55 + 0.0260X_9$
N uptake	-23.83	0.0255	0.954	$Y = -23.83 + 0.0255X_{10}$
P uptake	-3.9	0.0048	0.98	$Y = -3.90 + 0.0048X_{11}$
K uptake	41.87	0.0143	0.911	$Y = 41.87 + 0.0143X_{12}$
N removal	23.22	-0.0035	0.851	$Y = 23.22 - 0.0035X_{13}$
P removal	3.29	-0.0005	0.667	$Y = 3.29 - 0.0005X_{14}$
K removal	13.56	-0.002	0.67	$Y = 13.56 - 0.0020X_{15}$

Fig. 1. Positive Linear regression relationship of grain yield (Kg ha-1) with stover yield (Kg ha-1), Leaf Area Index, and Weed Control Efficiency

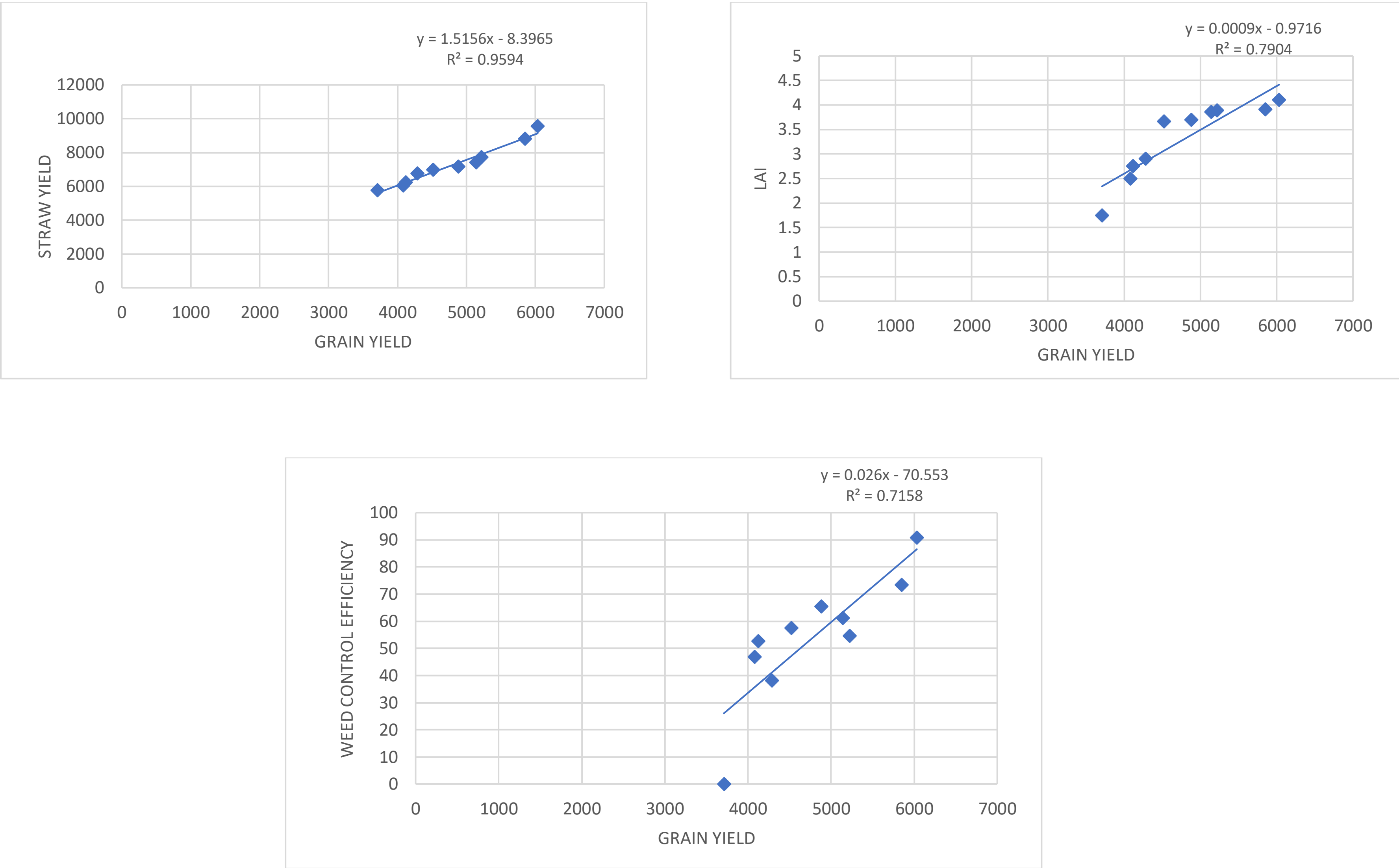

Fig. 2. Negative Linear regression relationship of grain yield (Kg ha^{-1}) with weed density at harvest stage, weed dry weight harvest stage (Kg ha^{-1}), Nutrient removal by weeds (Kg ha $^{-1}$)