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Effect of Organic and Inorganic Amendments on Growth, Yield Attributes and Yield of Wheat in Sodic *Vertisols* of Nimar Valley

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Abstract

A field experiment was conducted at the AICRP on Management of Saline Water and Associated Salinization in Agriculture, RVSKVV, College of Agriculture, Indore, at Salinity Research Farm, Baphalgaon, Barwaha, District Khargone (M.P.), to evaluate the effects of gypsum and *Gliricidia sepium* green leaf biomass on the growth and yield of wheat under sodic Vertisols. The experiment was laid out in a split-plot design with three replications and comprised three levels of gypsum requirement (0, 50 and 75% GR) and three levels of *Gliricidia* biomass (0, 5 and 10 t ha^{-1}). The results showed that increasing levels of gypsum and *Gliricidia* significantly improved plant population, plant height, number of tillers, dry matter accumulation, yield attributes, and wheat yield. The 75% GR treatment recorded the highest plant population (130.0 m^{-2}), plant height at harvest (89.1 cm), tillers per plant (6.60), dry matter accumulation (22.73 g plant^{-1}), grain spikes (19.8 plant^{-1}), test weight (24.02 g), grain yield

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(3878.3 kg ha^{-1}), straw yield (5150.0 kg ha^{-1}), and biological yield (9028.3 kg ha^{-1}). Similarly, the application of 10 t ha^{-1} *Gliricidia* produced superior growth and yield parameters. The combined use of gypsum and *Gliricidia* was effective in improving wheat productivity under sodic soil conditions. The study indicates that the integrated application of 75% gypsum requirement together with 10 t ha^{-1} *Gliricidia* biomass is a promising strategy for sustainable wheat production in sodic Vertisols of the Nimar Valley.

Keywords: Wheat; sodic Vertisols; gypsum requirement; Gliricidia sepium; green leaf biomass; soil amendment; crop growth; grain yield.

1. Introduction

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops worldwide and constitutes a major source of food, energy, and nutrition for a substantial proportion of the global population. In India, wheat occupies a central position in the agricultural economy and makes a major contribution to national food and nutritional security. However, wheat productivity is constrained by several soil-related limitations, among which sodicity represents a particularly serious problem in many parts of the country. Sodic *Vertisols* are typically characterised by high soil pH, elevated exchangeable sodium percentage (ESP), poor structural stability, low permeability, restricted water infiltration, and reduced availability of essential plant nutrients, all of which adversely affect root development and crop performance (Ali *et al*., 2025).

In the Nimar Valley region of Madhya Pradesh, the occurrence of sodic *Vertisols* poses a substantial challenge to sustainable wheat production because of their unfavourable physical and chemical properties. Excessive accumulation of sodium on the soil exchange complex promotes the dispersion of clay particles, resulting in the deterioration of soil structure, reduced porosity, poor aeration, and diminished hydraulic conductivity. These changes restrict water movement and root penetration and can ultimately lead to considerable reductions in crop productivity. Effective reclamation of sodic soils therefore requires appropriate soil-management practices capable of improving their physical, chemical, and biological properties (Gupta & Abrol, 1990; Richards, 1954).

Among the various inorganic soil amendments available for sodic soil reclamation, gypsum ($CaSO_4 \cdot 2H_2O$) is widely regarded as one of the most effective. Gypsum provides a readily soluble source of calcium, which replaces exchangeable sodium on soil colloidal surfaces and facilitates the subsequent leaching of displaced sodium from the root zone. This process reduces soil pH and ESP while improving aggregate stability, infiltration, permeability, and nutrient availability (Qadir *et al*., 2008; Sharma & Minhas, 2005). Although gypsum is highly effective in ameliorating the chemical constraints associated with sodicity, its capacity to increase soil organic matter content or stimulate soil biological activity is relatively limited when it is applied alone.

Organic amendments therefore have an important complementary role in restoring soil fertility and sustaining crop productivity in sodic environments. The incorporation of organic materials, including farmyard manure, vermicompost, compost, crop residues, and green leaf biomass, can increase soil organic carbon, stimulate microbial activity, improve nutrient cycling, and enhance aggregate stability (Choudhary *et al*., 2004). Organic inputs can also improve soil physical conditions by increasing water-holding capacity, reducing bulk density, and promoting better root proliferation. Moreover, the decomposition of organic matter releases organic acids and other metabolites that may contribute to reductions in soil alkalinity and improvements in nutrient availability. Previous studies have demonstrated that organic amendments can facilitate the displacement of exchangeable sodium by calcium and enhance the leaching of soluble salts, thereby contributing to the reclamation of sodic soils (Yadav *et al*., 2003).

Among potential organic resources, green leaf biomass from *Gliricidia sepium* has attracted considerable attention because of its rapid decomposition, relatively high nutrient content, and capacity to improve soil fertility. *Gliricidia* biomass is particularly rich in nitrogen and organic matter, and its incorporation into soil can stimulate microbial activity and accelerate nutrient mineralisation. The addition of *Gliricidia* leaves may also increase soil organic carbon, improve nutrient cycling, and promote the formation and stability of soil aggregates. When applied in combination with gypsum, *Gliricidia* biomass may provide complementary benefits by improving calcium-mediated sodium displacement while simultaneously enhancing microbial processes and increasing organic matter accumulation. Such combined effects may accelerate the restoration of favourable soil conditions in sodic *Vertisols*.

Integrated nutrient and soil amendment management is therefore considered a promising approach for improving nutrient availability and reducing sodicity-related hazards. The combined application of organic and inorganic amendments can improve the availability of major plant nutrients while contributing to reductions in sodium adsorption ratio (SAR) and residual sodium carbonate (RSC), thereby creating a more favourable soil environment for crop growth (Yaduvanshi & Sharma, 2016). Soil-quality indicators such as pH, electrical conductivity of the saturation extract (ECe), organic carbon content, available nutrients, soluble ion concentrations, ESP, SAR, and RSC are important parameters for assessing the extent of soil degradation and the effectiveness of reclamation measures.

Improvements in these soil properties through the integrated application of amendments can enhance root-zone conditions and support better wheat growth, nutrient uptake, and yield. Consequently, sustainable management of sodic *Vertisols* requires an integrated approach that combines the relatively rapid ameliorative effects of inorganic amendments such as gypsum with the longer-term benefits of organic inputs. Such a strategy has the potential not only to reduce soil sodicity but also to improve soil fertility, biological functioning, and overall soil quality, thereby supporting sustained wheat productivity under sodic soil conditions.

Recent field evidence indicates that gypsum application can improve wheat growth, yield, and mineral nutrition under saline-sodic conditions, while its integration with organic amendments can further support soil physical, chemical, and biological functions and crop productivity (Morsy et al., 2022; Rashmi et al., 2024; Tian et al., 2024).

Studies from other salt-affected systems similarly indicate that combining gypsum with biochar, farmyard manure, and related biological inputs can improve wheat performance in sodic soils, and that phosphogypsum can contribute to sodic-soil reclamation and crop response (Chadha et al., 2025; Hasana, 2026).

Research gap: Although the available evidence supports integrated amendment strategies, the combined effects of graded gypsum requirements and *Gliricidia sepium* green leaf biomass on wheat grown in sodic Vertisols of the Nimar Valley have not been sufficiently characterised. Site-specific evidence is particularly limited for crop establishment, vegetative growth, yield attributes, and yield under these conditions.

Objective: This study aimed to evaluate the individual and combined effects of three gypsum requirement levels and three *Gliricidia sepium* green leaf biomass rates on the growth, yield attributes, and yield of wheat cultivated in sodic Vertisols of the Nimar Valley.

2. Methodology

The field experiment was conducted during the r*abi* season at the AICRP on Management of Saline Water and Associated Salinization in Agriculture, RVSKVV, College of Agriculture, Indore, Salinity Research Farm, Baphalgaon, Barwaha, District Khargone (Madhya Pradesh). The experimental site is situated in the Nimar Valley region and is characterised by semi-arid climatic conditions. The soil of the experimental field was a sodic Vertisol with a high soil pH, poor soil structure, low permeability, and excessive sodium accumulation, all of which adversely affect crop growth and productivity. The experiment was laid out in a split-plot design with three replications. The treatments consisted of three levels of gypsum requirement in the main plots, viz., 0% GR, 50% GR, and 75% GR, and three levels of *Gliricidia* green leaf biomass (0, 5, and 10 t ha^{-1}) in the subplots, resulting in a total of nine treatment combinations. Each plot measured 5.5 m × 10 m. Gypsum was applied according to the prescribed treatments and incorporated thoroughly into the soil before sowing. *Gliricidia* green leaf biomass was incorporated into the soil approximately fifteen days before sowing to facilitate decomposition and nutrient release. Wheat was sown following the recommended agronomic practices for the region. Uniform crop management practices, including irrigation, weed control, and plant protection measures, were adopted in all treatments throughout the crop-growing period. Observations of crop growth parameters, such as plant population, plant height, number of tillers per plant, and dry matter accumulation, were recorded at different growth stages. Yield attributes, including the number of grain spikes per plant and test weight, were recorded at maturity. Grain yield, straw yield, biological yield, and harvest index were determined after harvest. The experimental data were statistically analysed using a split-plot design. The significance of treatment effects was tested by the F-test at the 5% level of significance, and critical differences (CD) were calculated wherever treatment effects were significant.

3. Results and Discussion

3.1 Effect of Organic and Inorganic Amendments on Growth Parameters of Wheat

The growth parameters of wheat were significantly influenced by the application of gypsum and *Gliricidia* green leaf biomass. Plant population increased with higher levels of both amendments. The highest plant population (130.0 m^{-2}) was recorded under 75% gypsum requirement (GR), whereas the lowest (122.3 m^{-2}) was observed under 0% GR. Similarly, the application of 10 t ha^{-1} *Gliricidia* recorded the maximum plant population (130.7 m^{-2}). The improved plant establishment might be attributed to better soil structure, enhanced moisture retention, and reduced sodium toxicity. Similar findings were reported by Sharma and Minhas (2005), who observed that gypsum application improved soil physical properties and crop establishment in sodic soils.

Plant height increased significantly with increasing levels of gypsum and *Gliricidia*. The highest plant height at harvest (89.1 cm) was recorded under 75% GR, while *Gliricidia* application at 10 t ha^{-1} produced the tallest plants (90.4 cm). The increase in plant height may be attributed to enhanced nutrient availability and improved root growth under ameliorated soil conditions. These findings are in agreement with those reported by Choudhary *et al.* (2004) and Cuevas *et al.* (2019), who observed significant increases in plant growth following the combined application of organic and inorganic soil amendments.

The number of tillers per plant also increased significantly following amendment application. At harvest, the highest number of tillers (6.60 plant^{-1}) was recorded under 75% GR, while *Gliricidia* at 10 t ha^{-1} produced 6.80 tillers plant^{-1}. Improved tillering could be attributed to increased nitrogen availability, better root proliferation, and enhanced nutrient uptake. Similar observations were reported by Mahajan *et al.* (2008), who found that integrated nutrient management significantly improved tiller production in wheat.

Dry matter accumulation followed a similar trend. The highest dry matter accumulation (22.73 g plant^{-1}) was recorded under 75% GR, while the application of 10 t ha^{-1} *Gliricidia* resulted in the maximum dry matter accumulation (23.70 g plant^{-1}). Enhanced biomass production under integrated amendment application may be due to improved soil fertility and greater photosynthetic activity. These findings corroborate those of Gheyi *et al.* (2022), who observed increased biomass accumulation in wheat following the application of organic amendments along with chemical soil conditioners.

3.2 Effect of Organic and Inorganic Amendments on Yield Attributes

Yield attributes were significantly affected by gypsum and *Gliricidia* application. The number of grain spikes per plant increased from 16.4 in the control to 19.8 under 75% GR. Likewise, *Gliricidia* application improved spike formation compared with the untreated plots. Improved spike production may be due to better nutrient availability throughout the crop growth period. Similar results were reported by Yadav *et al.* (2003), who found that organic amendments improved reproductive growth and spike development in wheat grown under problem soils.

Test weight also increased significantly following amendment application. The highest test weight (24.02 g) was recorded under 75% GR, while *Gliricidia* at 10 t ha^{-1} produced a test weight of 22.48 g. Improved grain development under integrated amendment application may be attributed to enhanced nutrient translocation and efficient grain filling. Similar findings were reported by Karforma *et al.* (2012), who observed increased test weight and grain quality due to organic matter incorporation and improved nutrient availability.

3.3 Effect of Organic and Inorganic Amendments on Grain Yield, Straw Yield and Biological Yield

Grain yield increased significantly with increasing levels of gypsum and *Gliricidia*. The highest grain yield (3878.3 kg ha^{-1}) was recorded under 75% GR, whereas the lowest yield (3230.0 kg ha^{-1}) was observed in the control. Among *Gliricidia* treatments, 10 t ha^{-1} produced the maximum grain yield (4030.0 kg ha^{-1}). The increase in grain yield may be attributed to improved soil physical conditions, enhanced nutrient uptake, and reduced adverse effects of sodicity. Similar results were reported by Qadir *et al.* (2008), who demonstrated that gypsum application significantly improved wheat productivity through reclamation of sodic soils.

Straw yield and biological yield also increased significantly with amendment application. The highest straw yield (5150.0 kg ha^{-1}) and biological yield (9028.3 kg ha^{-1}) were recorded under 75% GR. The application of 10 t ha^{-1} *Gliricidia* resulted in the highest straw yield (5306.7 kg ha^{-1}) and biological yield (9336.7 kg ha^{-1}). The increase in biomass production may be attributed to improved soil fertility, increased microbial activity, and enhanced nutrient cycling. These results are consistent with the findings of Yaduvanshi and Sharma (2016), who reported higher biomass production in wheat under integrated management of organic and inorganic amendments in sodic Vertisols.

Table 1. Effect of organic and inorganic amendments on growth parameters and yields of wheat

Treatments	Plant Population (m^{-2})	Plant height (cm)			Number of tillers per plant			Dry matter accumulation at harvesting stage (g)
		30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest	
Main plot: Gypsum application								
GR 0%	122.3	19.9	55.4	81.7	3.13	4.93	5.57	20.03
GR 50%	127.0	21.5	59.0	86.0	3.57	5.47	6.17	21.57
GR 75%	130.0	22.6	61.5	89.1	3.80	5.83	6.60	22.73
SEm ±	0.14	0.02	0.06	0.09	0.003	0.005	0.005	0.02
C.D. at 5%	0.56	0.08	0.24	0.36	0.011	0.019	0.021	0.08
Sub plot: Gliricidia application								
G1- 0 t ha^{-1}	122.3	19.5	54.5	80.6	3.00	4.73	5.40	19.27
G 2- 5 t ha^{-1}	126.3	21.4	58.8	85.7	3.50	5.43	6.13	21.37
G 3- 10 t ha^{-1}	130.7	23.1	62.6	90.4	4.00	6.07	6.80	23.70
SEm ±	0.15	0.03	0.07	0.10	0.005	0.007	0.008	0.03
C.D. at 5%	0.45	0.08	0.22	0.31	0.014	0.022	0.024	0.08
Interaction: Gypsum x Gliricidia application								
SEm ±	0.26	0.05	0.13	0.18	0.08	0.012	0.013	0.05
C.D. at 5%	0.79	0.14	0.38	0.54	0.025	0.037	0.041	0.14

Table 2. Effect of organic and inorganic amendments on yield parameters and yields of wheat

Treatments	Yield parameters and yield					
	Number of grain $spikes^{-1}$	Test weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index
Main plot: Gypsum application						
GR 0%	16.4	20.62	3230.0	4483.3	7713.3	41.8
GR 50%	17.8	22.02	3606.7	4893.3	8500.0	42.4
GR 75%	19.8	24.02	3878.3	5150.0	9028.3	42.9
SEm ±	0.02	0.02	34.85	47.92	82.76	-
C.D. at 5%	0.07	0.09	136.85	188.17	324.95	-
Sub plot: Gliricidia application						
G1- 0 t ha^{-1}	17.7	21.89	3110.0	4381.7	7491.7	41.5
G 2- 5 t ha^{-1}	18.0	22.29	3575.0	4838.3	8413.3	42.5
G 3- 10 t ha^{-1}	18.2	22.48	4030.0	5306.7	9336.7	43.1
SEm ±	0.02	0.03	24.96	33.33	58.27	-
C.D. at 5%	0.07	0.08	76.91	102.71	179.54	-
Interaction: Gypsum x Gliricidia application						
SEm ±	0.04	0.05	43.2	57.7	100.9	-
C.D. at 5%	0.11	0.14	133.2	177.9	310.9	-

Harvest index showed only slight variation among treatments, ranging from 41.5% to 43.1%. The highest harvest index was recorded under 10 t ha^{-1} *Gliricidia*, indicating better partitioning of assimilates towards grain production. Similar observations were reported by Ali *et al.* (2025), who found that integrated amendment application improved crop productivity and harvest efficiency in sodic soils.

Overall, the present findings indicate that the combined use of gypsum and *Gliricidia* green leaf biomass significantly improved wheat growth, yield attributes, and yield under sodic Vertisols of the Nimar Valley. The results are in close agreement with earlier findings reported by Sharma and Minhas (2005), Qadir *et al.* (2008), Mahajan *et al.* (2008), Yaduvanshi and Sharma (2016), and Gheyi *et al.* (2022), among other researchers working on sodic soil reclamation and integrated nutrient management.

4. Conclusion

The study indicates that both gypsum and *Gliricidia sepium* green leaf biomass improved wheat growth, yield attributes, and yield under sodic Vertisols of the Nimar Valley. The 75% gypsum-requirement treatment recorded the highest values for major growth and yield parameters among the gypsum treatments, while the 10 t ha^{-1} *Gliricidia* treatment produced the best performance among the organic amendment levels. These results suggest that combining inorganic reclamation through gypsum with organic biomass addition can support wheat productivity in sodic soils. However, the recommendation of a specific treatment combination should be supported by complete interaction means and economic analysis.

5. Limitations

The experiment was conducted at a single location during one rabi season, which limits the broader temporal and spatial applicability of the findings. Complete gypsum-by-Gliricidia interaction means were not presented. In addition, treatment-wise economic returns were not evaluated. Multi-season and multi-location validation, together with complete interaction and economic analyses, is therefore required before making a definitive field recommendation.

Declaration of AI Use

This manuscript was prepared through the intellectual contributions of the author(s) to the study design, data analysis, interpretation of results, and scholarly content. Grammarly and ChatGPT were used solely to assist with grammatical refinement and reference formatting during manuscript revision. The author(s) accept full responsibility for the accuracy, integrity, and final content of the manuscript.

Competing Interests

Authors have declared that no competing interests exist.

References

Ali, U., Shah, S. N., Khaskheli, M. A., Laghari, A. H., Arain, Z. A., Shehzad, M., & Laghari, A. J. (2025). Impact of salinity stress on major cereal crops and integrated management strategies for sustainable production. *Journal of Applied Research in Plant Sciences, 6*(2), 176–193. https://doi.org/10.38211/joarps.2025.06.328

Chadha, D., Sharma, V., Arya, V. M., Abrol, V., Bharat, R., Singh, B., Bhat, A., Sharma, D., Bhagat, V., Khenrab, S., & Banti. (2025). Influence of biochar and amendment application on performance of wheat in sodic soils. *Journal of Advances in Biology & Biotechnology, 28*(1), 792–799. https://doi.org/10.9734/jabb/2025/v28i11934

Choudhary, O. P., Josan, A. S., Bajwa, M. S., & Kapur, M. L. (2004). Effect of sustained sodic and saline-sodic irrigation and application of gypsum and farmyard manure on yield and quality of sugarcane under semi-arid conditions. *Field Crops Research, 87*(2–3), 103–116. https://doi.org/10.1016/j.fcr.2003.10.001

Cuevas, J., Daliakopoulos, I. N., del Moral, F., Hueso, J. J., & Tsanis, I. K. (2019). A review of soil-improving cropping systems for soil salinization. *Agronomy, 9*(6), 295. https://doi.org/10.3390/agronomy9060295

Gheyi, H. R., Lacerda, C. F., Freire, M. B. G. S., Costa, R. N. T., Souza, E. R., Silva, A. O., Fracetto, G. G. M., & Cavalcante, L. F. (2022). Management and reclamation of salt-affected soils: General assessment and experiences in the Brazilian semiarid region. *Revista Ciência Agronômica, 53*, e20217917. https://doi.org/10.5935/1806-6690.20220058

Gupta, R. K., & Abrol, I. P. (1990). Salt-affected soils: Their reclamation and management for crop production. In R. Lal & B. A. Stewart (Eds.), *Advances in soil science* (Vol. 11, pp. 223–288). Springer. https://doi.org/10.1007/978-1-4612-3322-0_7

Hasana, H. (2026). Evaluation of phosphogypsum application rates on sodic soil reclamation and haricot bean performance. *Asian Journal of Plant and Soil Sciences, 11*(1), 67–76. https://doi.org/10.56557/ajopss/2026/v11i1128

Karforma, J., Ghosh, M., Ghosh, D. C., & Mandal, S. (2012). Effect of integrated nutrient management on growth, productivity, quality and economics of fodder maize in rainfed upland of Terai region of West Bengal. *International Journal of Agriculture, Environment and Biotechnology, 5*(4), 419–427. https://bausabour.ac.in/department_details.aspx?cc=001&deptcode=Agronomy

Mahajan, A., Bhagat, R. M., & Gupta, R. D. (2008). Integrated nutrient management in sustainable rice–wheat cropping system for food security in India. *SAARC Journal of Agriculture, 6*(2), 1–16. https://www.sac.org.bd/archives/journals/sja_v_6_i_2_2008.pdf

Morsy, S., Elbasyoni, I. S., Baenziger, S., & Abdallah, A. M. (2022). Gypsum amendment influences performance and mineral absorption in wheat cultivars grown in normal and saline-sodic soils. *Journal of Agronomy and Crop Science, 208*(5), 675–692. https://doi.org/10.1111/jac.12598

Qadir, M., Tubeileh, A., Akhtar, J., Larbi, A., Minhas, P. S., & Khan, M. A. (2008). Productivity enhancement of salt-affected environments through crop diversification. *Land Degradation & Development, 19*(4), 429–453. https://doi.org/10.1002/ldr.853

Rashmi, I., Meena, B. P., Rajendiran, S., Jayaraman, S., Joshy, C. G., Ali, S., Mina, B. L., Kumar, K., Kumar, A., Kumawat, A., & Kala, S. (2024). Can gypsum and organic amendments achieve sustainability, productivity and maintain soil health under soybean–mustard cropping in sodic soils of western India. *Soil and Tillage Research, 240*, 106075. https://doi.org/10.1016/j.still.2024.106075

Richards, L. A. (Ed.). (1954). *Diagnosis and improvement of saline and alkali soils* (Agriculture Handbook No. 60). U.S. Department of Agriculture. https://www.ars.usda.gov/pacific-west-area/riverside-ca/agricultural-water-efficiency-and-salinity-research-unit/docs/publications/handbook-no-60/

Sharma, B. R., & Minhas, P. S. (2005). Strategies for managing saline/alkali waters for sustainable agricultural production in South Asia. *Agricultural Water Management, 78*(1–2), 136–151. https://doi.org/10.1016/j.agwat.2005.04.019

Tian, Y., Jiang, W., Chen, G., Wang, X., & Li, T. (2024). Gypsum and organic materials improved soil quality and crop production in saline-alkali on the loess plateau of China. *Frontiers in Environmental Science, 12*, 1434147. https://doi.org/10.3389/fenvs.2024.1434147

Yadav, J. S. P. (2003). Managing soil health for sustained high productivity. *Journal of the Indian Society of Soil Science, 51*(4), 448–465. https://epubs.icar.org.in/index.php/JISSS

Yaduvanshi, N. P. S., & Sharma, D. R. (2016). Utilization of organics, amendment and fertilizers with sodic water irrigation: Long-term effect on soil properties and rice–wheat productivity. *Journal of the Indian Society of Soil Science, 64*(3), 254–261. https://epubs.icar.org.in/index.php/JISSS/article/view/66417

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