



Data Article

Data describing the eco-physiological responses of *Elaeagnus angustifolia* grown under contrasting regime of water and fertilizer in coal-mined spoils



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ABSTRACT

To improve our understanding of how coal mining areas can be re-vegetated and ecosystem function restored, we examined the potential effects of five water (W) regimes (40, 50, 60, 70 and 80% of field capacity), five nitrogen (N) (0, 24, 60, 96 and 120 mg kg⁻¹ soil) and five phosphorus (P) fertilizer doses (0, 36, 90, 144 and 180 mg kg⁻¹ soil), which control the growth and development of *Elaeagnus*

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Keywords:

Coal spoils
 Nutrient fertilization
 Response surface methodology
 Vegetation restoration
 Water shortage

angustifolia under adverse environmental conditions. To optimize the W-N-P application rate, three factors and five levels of central composite design along with an optimization technique named response surface methodology were utilized. Here we provide data on root-shoot biomass ratio, leaf dry matter content, stomatal conductance, chlorophyll (Chl) *a*, Chl *b*, membrane stability index and soluble protein content of *E. angustifolia*. The data described in this article are available in Mendeley Data, DOI: [10.17632/2vfbrdxyf2.2](https://doi.org/10.17632/2vfbrdxyf2.2) [1]. These data could be used to evaluate the improvement in growth performance of *E. angustifolia* subjected to various regimes of W, N and P. This dataset showed that *E. angustifolia* grew optimally in coal-mine spoils when irrigated at 66% of field capacity and supplemented with 74.0 mg N and 36.0 mg P kg⁻¹ soil. This could considerably help the success of revegetation in coal-mined degraded arid areas where W is scarce. This article contains data complementary to the main research entitled "Fine-tuning of soil water and nutrient fertilizer levels for the ecological restoration of coal-mined spoils using *Elaeagnus angustifolia*" in the Journal of Environmental Management (Roy et al., 2020).

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Specifications Table

Subject	Agricultural and Biological Science
Specific subject area	Plant Physiology, Plant nutrition
Type of data	Table, Figure
How the data were acquired	The CIRAS-3 (Portable Photosynthesis System, Amesbury, MA, USA) was used to assess the stomatal conductance of <i>Elaeagnus angustifolia</i> seedlings. Chlorophyll (Chl) <i>a</i> and Chl <i>b</i> were extracted from fully expanded leaves as described by Roy et al. [2]. In brief, 100 mg of fresh leaves were placed in a test tube and combined with 10 mL mixture of acetone, ethanol and water (4.5:4.5:1) and kept overnight at 4 °C in a dark condition. The absorbance of the extracts was taken at 645, 663 and 470 nm using a Pharmacia Ultra Spec Pro UV/VIS spectrophotometer (Cambridge, England), and the contents of Chl <i>a</i> and Chl <i>b</i> were calculated according to the formula of Arnon [3]. The membrane stability index of <i>E. angustifolia</i> leaves was assessed with the help of a conductivity meter. Soluble protein concentration was measured in the crude extract by the method of Bradford [4] using bovine serum albumin as a standard. The response surface methodology was used for analyzing the effects of three independent variables [like water (W), nitrogen (N), phosphorus (P)] on the response variables.
Data format	Raw Analyzed
Experimental factors	The W, N, and P were the study's independent variables, while integrated growth performance was the response variable.
Parameters for data collection	Coal-mined spoil was taken from the Yangchangwan coal mining site in Lingwu, Ningxia, China. Shovels were used to gather spoil samples from the surface at a depth of 50 cm, which were then consolidated, dried in the open air, crushed by hand, and sieved through a mesh of 2 mm. One-year-old similar <i>E. angustifolia</i> seedlings were planted into 14 kg of coal spoils in plastic pots (320 mm upper diameter, 270 mm bottom diameter) in early March 2018. Seedlings were watered daily for the first month to guarantee proper establishment in pots, after which water-stress treatments began and followed for five months. Pots were watered

(continued on next page)

Description of data collection	daily to keep water content at field capacity for different water treatments, according to the weight method described by Roy et al. [2]. The N-fertilizer (in the form of urea) was applied at 4 times ($\frac{1}{4}$ N at every one month interval) and P was given (in the form of triple superphosphate) in two halves. Plant growth attributes were measured at the end of the experimental period. Gas-exchange parameters were taken on a sunny day during the hours of 8:30 am to 11:30 am [5].
Data source location	Northwest A&F University, Yangling (N 34°16', E 108°4'), Shaanxi, 712100, China.
Data accessibility	Repository name: MendelyData Data identification number: 10.17632/2vfbrdxyf2.2 Direct URL to data: https://data.mendeley.com/datasets/2vfbrdxyf2/2
Related research article	R. Roy, J. Wang, M.G. Mostafa, D. Fornara, A. Sikdar, T. Sarker, X. Wang, M. Shah, Fine-tuning of soil water and nutrient fertilizer levels for the ecological restoration of coal-mined spoils using <i>Elaeagnus angustifolia</i> . J. Environ. Manage. 270 (2020) 110,855. https://doi.org/10.1016/j.jenvman.2020.110855

Value of the Data

- These data will be useful for researchers interested in revegetation in coal-mined degraded arid areas, worldwide.
- This data will be useful to understand the potential impact of W, N and P on the revegetation of *E. angustifolia* grown in drought-prone coal mine spoils.
- These data can be used by researchers to implement more efficient and effective field research after reviewing how different combinations of W, N and P interact on physiological parameters of *E. angustifolia* and how optimum W-N-P doses facilitate revegetation intervention programs.

1. Data Description

This dataset contains two tables and four figures. Data provided in [Table 1](#) shows the interaction effect of W, N and P on root-shoot (R/S) biomass ratio, leaf dry matter content (LDMC), stomatal conductance (Gs), chlorophyll (Chl) *a*, Chl *b*, membrane stability index (MSI) and soluble protein (SP) content of *E. angustifolia*. The amount of W, N and P application is designated as a subscript in the treatment column (such as W_{70} = 70% field capacity, N_{96} = 96 mg kg^{-1} and P_{144} = 144 mg kg^{-1}). [Table 2](#) shows the desirability specifications of numerical optimization for central composite design. [Fig. 1](#) shows representative individual leaves of *E. angustifolia*. [Fig. 2](#) shows the interaction effect of W, N and P on (a–c) root-shoot (R/S) biomass ratio, (d–f) leaf dry matter content (LDMC), (g–i) stomatal conductance (Gs), (j–l) chlorophyll *a*, and (m–o) chlorophyll *b* in the leaves of *E. angustifolia*. [Fig. 3](#) shows the interaction effect of W, N and P on (a–c) membrane stability index (MSI) and (d–f) soluble protein (SP) content in the leaves of *E. angustifolia*. [Fig. 4](#) Pearson's correlation coefficient shows the effects of various regimes of W, N and P on the various growth responses of *E. angustifolia*. Raw and analysis of variance data of different responses associated with the figures are available at <https://data.mendeley.com/datasets/2vfbrdxyf2/2>.

Table 1

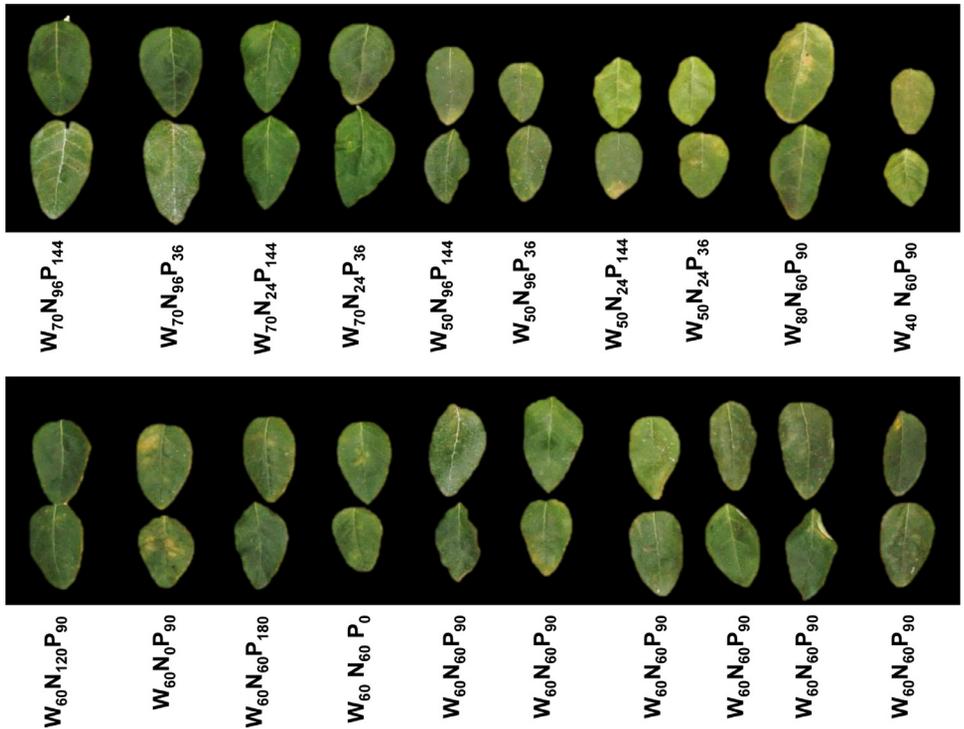
Interaction effect of water (W), nitrogen (N) and phosphorus (P) on root-shoot (R/S) biomass ratio, leaf dry matter content (LDMC), stomatal conductance (Gs), chlorophyll (Chl) a, Chl b, membrane stability index (MSI) and soluble protein (SP) content of *E. angustifolia*.

Treatments	R/S	LDMC g g ⁻¹	Gs mol m ⁻² s ⁻¹	Chl a mg g ⁻¹ FW	Chl b mg g ⁻¹ FW	MSI %	SP mg g ⁻¹ FW
W ₇₀ N ₉₆ P ₁₄₄	0.74 ± 0.01 ^{cde}	0.229 ± 0.01 ^b	0.263 ± 0.02 ^{abcd}	1.95 ± 0.13 ^{ab}	0.99 ± 0.13 ^a	55.17 ± 0.957 ^{de}	56.78 ± 2.5 ^{ab}
W ₇₀ N ₉₆ P ₃₆	0.76 ± 0.03 ^{bc}	0.235 ± 0.03 ^b	0.287 ± 0.02 ^a	2.07 ± 0.14 ^a	0.88 ± 0.04 ^{abcde}	54.45 ± 0.427 ^{def}	57.26 ± 1.1 ^a
W ₇₀ N ₂₄ P ₁₄₄	0.68 ± 0.03 ^f	0.236 ± 0.02 ^b	0.284 ± 0.01 ^{ab}	1.99 ± 0.08 ^{ab}	0.92 ± 0.06 ^{abc}	51.22 ± 3.664 ^g	31.59 ± 3.5 ^{fgh}
W ₇₀ N ₂₄ P ₃₆	0.7 ± 0.02 ^{def}	0.241 ± 0.03 ^b	0.239 ± 0.03 ^{abcde}	1.74 ± 0.15 ^{abcde}	0.84 ± 0.05 ^{abcdef}	53.22 ± 0.489 ^{efg}	25.07 ± 2 ^{hi}
W ₅₀ N ₉₆ P ₁₄₄	0.8 ± 0.02 ^{ab}	0.252 ± 0.01 ^b	0.212 ± 0.02 ^{cde}	1.45 ± 0.13 ^e	0.66 ± 0.04 ^{fgh}	45.03 ± 0.361 ^{hi}	50.29 ± 5.4 ^{bc}
W ₅₀ N ₉₆ P ₃₆	0.84 ± 0.02 ^a	0.262 ± 0.02 ^b	0.282 ± 0.01 ^{ab}	1.75 ± 0.18 ^{abcde}	0.72 ± 0.06 ^{defgh}	47.04 ± 0.879 ^h	51.77 ± 1.4 ^{abc}
W ₅₀ N ₂₄ P ₁₄₄	0.71 ± 0.03 ^{cdef}	0.267 ± 0.02 ^{ab}	0.252 ± 0.01 ^{abcde}	1.75 ± 0.15 ^{abcde}	0.77 ± 0.06 ^{bcdefg}	43.13 ± 0.368 ⁱ	26.1 ± 2.1 ^{ghi}
W ₅₀ N ₂₄ P ₃₆	0.74 ± 0.02 ^{cde}	0.265 ± 0.02 ^b	0.245 ± 0.01 ^{abcde}	1.67 ± 0.04 ^{bcde}	0.75 ± 0.02 ^{cdefgh}	43.99 ± 0.85 ⁱ	22.58 ± 1.6 ⁱ
W ₈₀ N ₆₀ P ₉₀	0.71 ± 0.02 ^{cdef}	0.231 ± 0.02 ^b	0.265 ± 0.02 ^{abcd}	1.88 ± 0.15 ^{abcd}	0.9 ± 0.03 ^{abcd}	55.48 ± 0.323 ^{cde}	45.48 ± 3.6 ^{cd}
W ₄₀ N ₆₀ P ₉₀	0.81 ± 0.02 ^{ab}	0.32 ± 0.03 ^a	0.235 ± 0.01 ^{abcde}	1.48 ± 0.09 ^e	0.58 ± 0.04 ^b	42.28 ± 0.339 ⁱ	27.88 ± 3.5 ^{ghi}
W ₆₀ N ₁₂₀ P ₉₀	0.8 ± 0.02 ^{ab}	0.242 ± 0.03 ^b	0.291 ± 0.02 ^a	1.66 ± 0.11 ^{bcde}	0.73 ± 0.04 ^{defgh}	52.12 ± 0.974 ^{fg}	56.36 ± 1.1 ^{ab}
W ₆₀ N ₀ P ₉₀	0.69 ± 0.02 ^{ef}	0.258 ± 0.02 ^b	0.268 ± 0.01 ^{abc}	1.58 ± 0.08 ^{cde}	0.69 ± 0.08 ^{fgh}	50.45 ± 0.431 ^g	24.27 ± 0.1 ⁱ
W ₆₀ N ₆₀ P ₁₈₀	0.72 ± 0.02 ^{cdef}	0.247 ± 0.01 ^b	0.196 ± 0.01 ^e	1.88 ± 0.06 ^{abcd}	0.94 ± 0.09 ^{ab}	52.08 ± 1.007 ^{fg}	39.3 ± 0.4 ^{de}
W ₆₀ N ₆₀ P ₀	0.76 ± 0.02 ^{bc}	0.257 ± 0.01 ^b	0.209 ± 0.02 ^{cde}	1.91 ± 0.15 ^{abc}	0.96 ± 0.08 ^a	47.4 ± 0.276 ^h	36.06 ± 0.5 ^{ef}
W ₆₀ N ₆₀ P ₉₀	0.74 ± 0.01 ^{cde}	0.255 ± 0.01 ^b	0.214 ± 0.01 ^{cde}	1.54 ± 0.12 ^e	0.67 ± 0.07 ^{fgh}	59.06 ± 0.538 ^{ab}	38.05 ± 0.8 ^{ef}
W ₆₀ N ₆₀ P ₉₀	0.73 ± 0.03 ^{cdef}	0.243 ± 0.01 ^b	0.226 ± 0.01 ^{bcde}	1.51 ± 0.1 ^e	0.64 ± 0.05 ^{gh}	57.16 ± 1.105 ^{bcd}	35.67 ± 0.8 ^{ef}
W ₆₀ N ₆₀ P ₉₀	0.72 ± 0.02 ^{cdef}	0.236 ± 0.02 ^b	0.208 ± 0.01 ^{cde}	1.55 ± 0.04 ^{de}	0.7 ± 0.07 ^{efgh}	58.35 ± 0.34 ^{abc}	32.57 ± 1.2 ^{efg}
W ₆₀ N ₆₀ P ₉₀	0.75 ± 0.03 ^{bcd}	0.259 ± 0.02 ^b	0.218 ± 0.01 ^{cde}	1.52 ± 0.06 ^e	0.66 ± 0.04 ^{fgh}	60.04 ± 0.547 ^{ab}	34.72 ± 2.3 ^{ef}
W ₆₀ N ₆₀ P ₉₀	0.73 ± 0.03 ^{cdef}	0.261 ± 0.02 ^b	0.205 ± 0.01 ^{de}	1.56 ± 0.06 ^{de}	0.69 ± 0.04 ^{fgh}	55.42 ± 0.151 ^{cde}	35.45 ± 2.6 ^{ef}
W ₆₀ N ₆₀ P ₉₀	0.74 ± 0.01 ^{cde}	0.256 ± 0.03 ^b	0.211 ± 0.01 ^{cde}	1.57 ± 0.11 ^{de}	0.65 ± 0.03 ^{gh}	61.22 ± 1.345 ^a	38.77 ± 3.1 ^{de}

Table 2

Specifications of desirability for numerical optimization in central composite design.

Name	Goal	Lower limit	Upper limit	Importance
Water (% FC)	minimize	40	80	3
Nitrogen (mg kg ⁻¹)	minimize	0	120	3
Phosphorus (mg kg ⁻¹)	minimize	0	180	3
Leaf dry matter content	is in range	0.68	0.84	3
Root-shoot ratio	is in range	0.229	0.32	3
Stomatal conductance	is in range	0.196	0.291	3
Chlorophyll <i>a</i>	is in range	1.45	2.07	3
Chlorophyll <i>b</i>	is in range	0.58	0.99	3
Membrane stability index	maximize	42.28	61.22	3
Soluble protein	maximize	22.58	57.26	3

**Fig. 1.** Representative individual leaves of *E. angustifolia*.

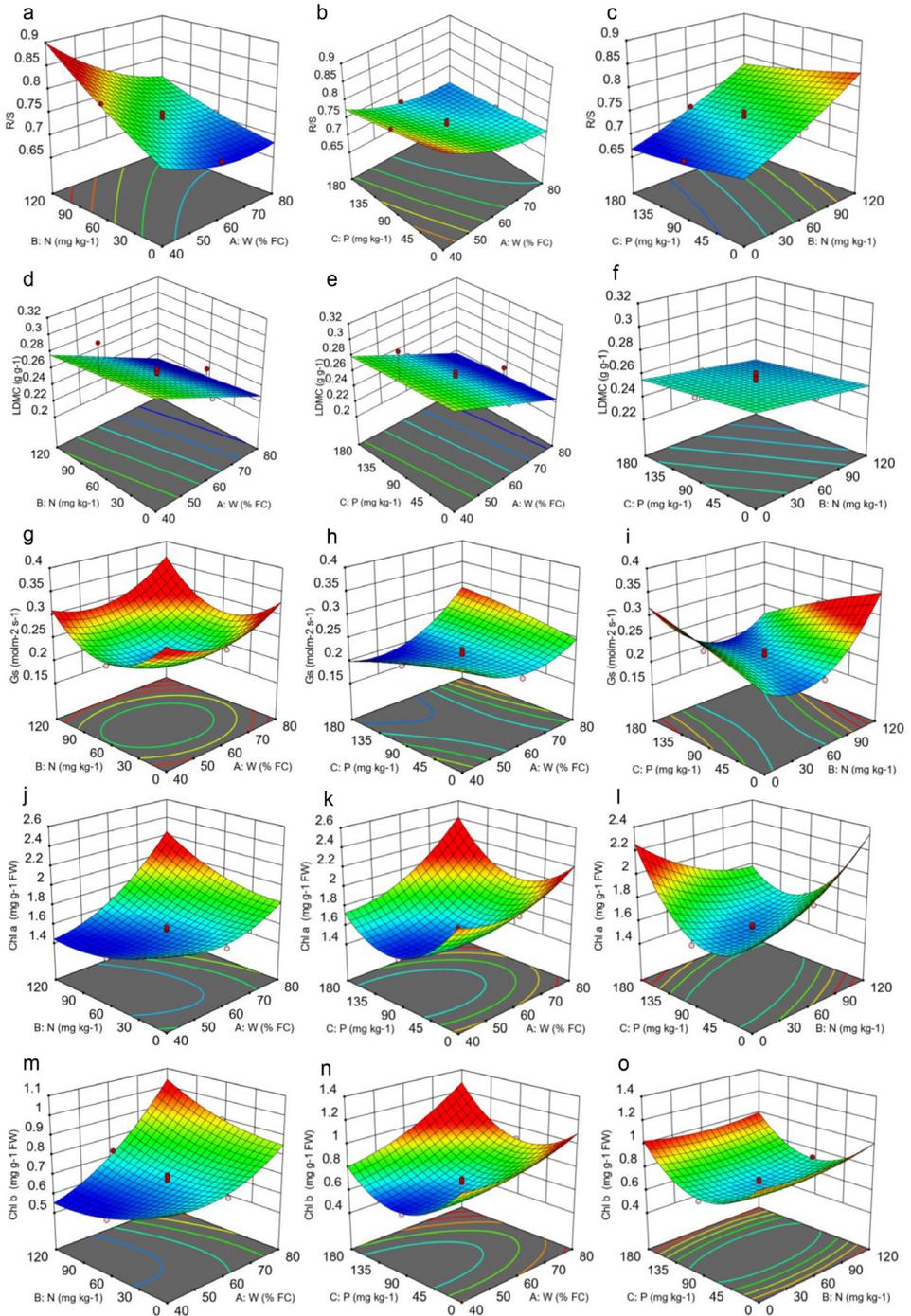


Fig. 2. The effects of various regimes of W and N-P doses on (a–c) root-shoot (R/S) biomass ratio, (d–f) leaf dry matter content (LDMC), (g–i) stomatal conductance (G_s), (j–l) chlorophyll a, and (m–o) chlorophyll b in the leaves of *E. angustifolia*.

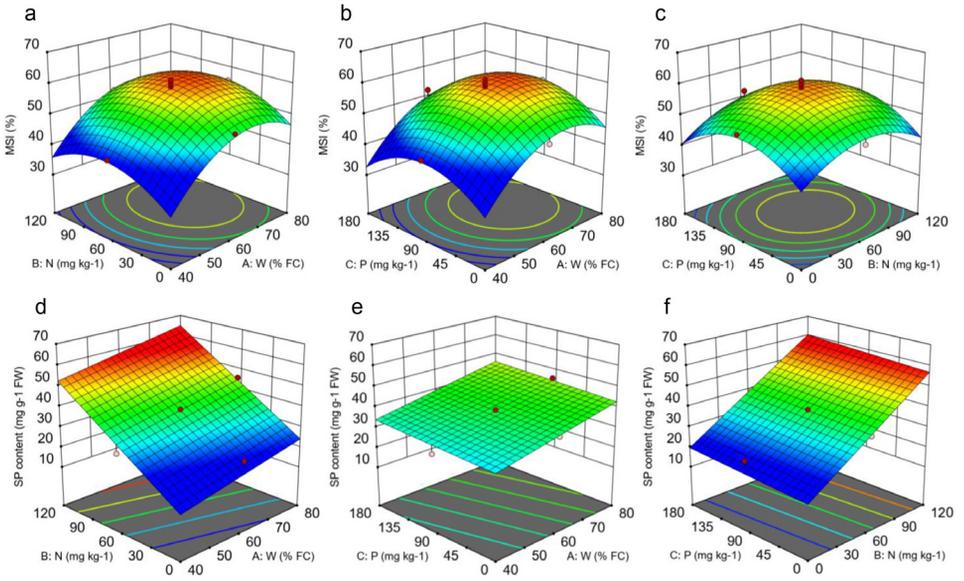


Fig. 3. The effects of various regimes of W and N-P doses on (a–c) membrane stability index (MSI) and (d–f) soluble protein (SP) content in the leaves of *E. angustifolia*.

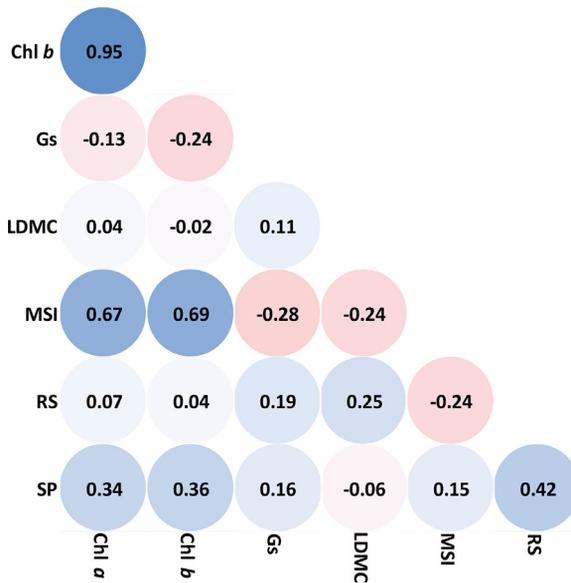


Fig. 4. Pearson's correlation coefficient shows the effects of various regimes of W and N-P doses on the various growth responses of *E. angustifolia*.

2. Experimental Design, Materials and Methods

2.1. Pot Experiment and Design

The pot experiment was conducted at Northwest Agriculture and Forestry University in Yangling, China, in a plastic shed. Coal-mined soil was taken from the Yangchangwan area of Lingwu, Ningxia, China. We used shovels to collect spoil materials at a depth of 50 cm, followed by air drying, bulking, hand crushing, and sifting through a 2 mm mesh. Exactly 14 kg of coal spoil were placed in plastic pots, and each pot was planted with a one-year-old identical *E. angustifolia* seedling at March 2018. Seedlings were watered daily for the first month to guarantee proper establishment in pots, after which water-stress treatments began and continued until October 2018. The quantity of moisture lost from each pot by transpiration and evaporation was determined using a weighing technique, and daily watering was performed throughout the study period [2]. The N-fertilizer (in the form of urea) was applied at 4 times ($\frac{1}{4}$ N at every one-month interval) and P was given (in the form of triple superphosphate) in two halves.

The experiment was designed using the central composite design (CCD) technique. CCD was used to produce 5 levels of each of three factor, and response surface methodology (RSM) was used to optimize the W–N–P rates. The following equation was used to code the independent variables in this study:

$$X_i = \frac{Z_i - Z_{i0}}{\Delta Z_i} \quad (1)$$

Here, X_i represents the coded value of the different independent variables; Z_i indicates the actual value of the independent variable; Z_{i0} denotes the actual value of Z_i at the center point; and ΔZ_i indicates the step change value. In our study, we used round values for N and P doses and nearest 10 for W doses.

The CCD consists of a set of 2^3 factorial runs, six axial points and six replicates at the center points. In total, 20 treatments were produced and each treatment was repeated 3 times ($3 \times 20 = 60$).

A second-order polynomial model was used to fit the experimental data as below:

$$Y = \beta_0 + \beta_1 A + \beta_2 B + \beta_3 C + \beta_{12} AB + \beta_{13} AC + \beta_{23} BC + \beta_{11} A^2 + \beta_{22} B^2 + \beta_{33} C^2 \quad (2)$$

Here, response variables are denoted by Y, and the constant coefficient is β_0 . Interpreted linear coefficients are represented by β_1 , β_2 and β_3 , and interactivity coefficients by β_{12} , β_{13} and β_{23} . Quadratic coefficients are denoted by β_{11} , β_{22} and β_{33} . Coded values of W, N, and P are denoted by A, B, and C.

2.2. Assessment of Morphological Parameters

The root-shoot (R/S) biomass ratio (dry weight basis) was measured by dividing below-ground biomass with above-ground biomass. The leaf dry matter content (LDMC) was measured for each leaf (ten leaves chosen from each treatment) as the ratio of the leaf dry weight to the leaf saturated fresh weight [6].

2.3. Determination of Stomatal Conductance and Photosynthesis Pigment Contents of *E. angustifolia* Leaves

Stomatal conductance of *E. angustifolia* leaves was measured using CIRAS-3 (Portable Photosynthesis System, Amesbury, MA, USA). Measurements were conducted on a sunny day during the hours of 8:30 am to 11:30 am. Chlorophyll (Chl) *a* and Chl *b* were extracted from fully expanded leaves as described by Roy et al. [2]. In brief, 100 mg of fresh leaves were placed in test tube and combined with 10 mL of ethanol, acetone and distilled water mixture (4.5:4.5:1) and

kept overnight at 4 °C in a dark condition. The absorbance was taken at 645, 663 and 470 nm using a Pharmacia Ultra Spec Pro UV/VIS spectrophotometer (Pharmacia, Cambridge, England), and the contents of Chl *a* and Chl *b* were calculated using the following formula of Arnon [3].

$$\text{Chl } a(\text{mg g}^{-1}\text{FW}) = [12.7 (A663) - -2.69(A645)] \times V/(1000 \times W) \quad (3)$$

$$\text{Chl } b(\text{mg g}^{-1}\text{FW}) = [22.9 (A645) - -4.68 (A663)] \times V/(1000 \times W) \quad (4)$$

where

A = Absorbance at specific wavelengths.

V = final volume of chlorophyll extract.

W = fresh weight of tissue extracted.

12.7, 2.69, 22.9 and 4.68 are the constants.

2.4. Estimation of Membrane Stability Index and Soluble Proteins

The membrane stability index of *E. angustifolia* leaves was measured using a conductivity meter. Ten leaf pieces (2 cm in diameter) were cut from fresh leaves and properly cleansed with double distilled water before being put in a test tube containing 15 ml of distilled water. The tubes were kept at room temperature overnight. Water conductance (T1) was measured using an electrical conductivity meter after incubation. The conductivity was measured (T2) again after autoclaving the test tubes for 10 min at 120 °C. The membrane stability index (MSI) was calculated as follows:

$$\text{MSI} = [1 - -(T1/T2)] \times 100 \quad (5)$$

The soluble protein was extracted from fresh leaf samples in a solution containing 50 mM sodium phosphate buffer (pH 7.8), followed by centrifugation at 10,000 rpm for 20 min at 4 °C. The supernatant was used to evaluate the soluble protein concentration using the Bradford technique [4] using bovine serum albumin as a standard.

2.5. Statistical Analysis and Optimization

The analysis of variance was performed to assess the individual and interaction effects of 3 independent variables (*W*, *N*, and *P*) on a variety of response variables. The numerical data in the tables and figures represent the means and standard errors (SEs) of 3 replicates for each treatment. The optimal *W-N-P* rate was determined using Derringer's desired function technique and Design Expert statistical software (version 11.0, Stat-Ease, Inc., Minneapolis, MN, USA). Pearson's correlation coefficients were shown as a matrix of correlations.

Ethics Statements

Not applicable.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

No data was used for the research described in the article.

CRediT Author Statement

Rana Roy: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Visualization, Writing – original draft, Writing – review & editing; **Jinxin Wang:** Conceptualization, Resources, Project administration, Funding acquisition; **Tanwne Sarker:** Investigation, Visualization; **Abdul Kader:** Writing – review & editing; **Ahmed Khairul Hasan:** Writing – review & editing; **Emre Babur:** Writing – review & editing.

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