RESEARCH ARTICLE

Unraveling the Relationship between Percentage Cover and Biomass of Various Herbaceous Species in the Dry Tropical Grassland

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Abstract

The estimation of biomass and cover is an ideal variable for determining ecosystem productivity, vegetation abundance, and community structure of any ecosystem. Biomass estimation by harvest method causes a huge loss of biomass and biodiversity. Non-destructive methods are helpful for repeated and regular sampling of the same plot to measure any change in biomass at the fixed time interval. There are already several regression equations established between biomass and cover in various ecosystems for finding above-ground biomass but there was an urgent need for such studies in dry tropical grasslands. The experiment was performed in the entire campus of Banaras Hindu University, Varanasi. 115 Quadrats were sampled in the entire university campus during year 2019-2020. For each quadrat, species-wise individual numbers were recorded and above-ground biomass was estimated by harvest method. Herbage cover was recorded for each species and measured by gridding each 1×1 m^2 quadrat into 100 cells of 10 × 10 cm cells, each representing 1% cover. We found 59 herbaceous species of 28 different families. The family Asteraceae was the most common while only single species represented the other seventeen families. Most of the species like *Dichanthium annulatum, Sida acuta, Ageratum conyzoides*, *Malvastrum coromandelianum*, *Rungia pectinate,* and *Vernonia cinerea* showed linear regression equation, *Parthenium hysterophorus, Alternenthera sessilis, Boerhavia diffusa* showed quadratic polynomial trendlines. Species like *Zephyranthes citrina* and *Ruellia tuberosa* showed a power regression equation. Only *Andrographis paniculata*, and *Chenopodium album* showed an exponential regression equation. A power regression equation was found between pooled biomass and cover. Using the regression equations biomass of the listed 59 species could be calculated easily without disturbing the vegetation of the study area which will eventually help in the conservation of nature.

Keywords: Dry tropical grassland, Percent cover, Regression equation, Biomass estimation.

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Introduction

With the increase in anthropogenic disturbances, climate change has resulted in various natural calamities like extreme weather conditions, increase in warming, high precipitation, frequent drought, and forest-fire, which leads to enormous loss of biodiversity, harm to ecosystem structure, function and adaptability (IPCC, 2022). Every plant species has its significance in an ecosystem, and loss of biodiversity may cause a detrimental effect on the balance in ecosystem sustenance which could ultimately endanger the survival of human beings (Lawton, 1998).

Grasslands play an incredible role in supporting biodiversity by providing shelters for seeds of plant species and food for domestic and wild animals (San Jose and Farinas, 1991). With their fibrous roots, grasslands bind the soil particle and help in preventing soil erosion (Smith, 1996). Grasslands are threatened by the risk of getting fragmented and degraded by anthropogenic activities (Sagar *et al*., 2017). That may result in biodiversity loss by significantly influencing the primary productivity and ecosystem functioning (Sagar *et al*., 2015). Grasslands are essential for global atmospheric carbon storage (C) (Verma *et al*., 2019). As they contain more than 10% of the carbon in the form of terrestrial biomass, 30% as soil organic carbon, and sequester 0.5 pentagrams of carbon every year (Follett and Reed, 2010; Qiu *et al*., 2013; Zhau *et al*., 2017).

Biomass, which is a component of plant structure, is used to estimate biodiversity loss and regulates the concentration of carbon that will be present into the atmosphere as CO_2 through respiration. It also serves as the most important source of food and energy for animals and humans (Houghton *et al*., 2009). According to Wilson (1991), biomass is the best indicator of productivity and measure of abundance in grassland communities. Quantification of biomass is essential for analyzing nutrient cycling of any ecosystem model for which direct method like harvesting of understory vegetation is also used, but this is a destructive as well as time-consuming method which needs to be replaced by an indirect and non-destructive method (Hermy, 1988; Chiarucci *et al*.,1999). To avoid the labor-intensive field work and loss of biomass by harvest method, an alternative approach for biomass estimation using cover as a correlation variable is required (Sala and Austin,2000). This non-destructive method is also helpful for repeated and regular sampling of the same plot to measure any change in biomass in the fixed time interval (Bråkenhielm and Liu, 1998).

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The herbaceous cover is another measure for determining the abundance of vegetation in grasslands, frequently used in field surveys; many methods have been developed for its visual estimation (Chen *et al*., 2008). It is determined by measuring the ground area covered by the plant's aerial parts; this gives an idea of changes in vegetation and the relative contribution of species in any community (Fenner, 1997).

The estimation of biomass and cover is an ideal variable for determining ecosystem productivity, vegetation abundance, and community structure of any ecosystem (MacDonald *et al*., 2012). There are already several regression equations established between biomass and cover in various ecosystems for finding above-ground biomass but, there need to be such studies on the relationship between percentage cover and biomass in dry tropical grasslands, enabling us to do the non-destructive estimation of biomass. So, the present study is based on establishing a relationship between biomass and cover in dry tropical grasslands using a regression equation with the following objectives:

- To collect herbaceous plant samples, estimation of its biomass, and cover.
- To establish the species-wise regression equation between biomass and cover.

Material And Methods

Study Area

The experiment was performed in the Banaras Hindu University campus (25.3176° N latitude and 82.9739° E longitude and 80.71 meter above sea level), Varanasi, India, from November 2019 – February 2020. The climate is tropical monsoon. Three different seasons are winter (November to February), summer (April to June), and rainy (July to September). October and March are considered as transitional months between rainy and winter and winter and summer, respectively (Verma *et al*., 2015).

Vegetation Sampling

A total of 115 quadrats were sampled and randomly selected in the campus of Banaras Hindu University. The number of individuals and their percentage cover was measured for each species by quadrat method and measured by gridding each 1×1 m^2 quadrat into 100 cells of 10 cm × 10 cm cell; each represents 1% cover (Sagar *et al*., 2008). For each Quadrat, species-wise above-ground biomass was estimated by harvest method in the lab.

Statistical analysis

Various regression equations and graphs between cover (C) and oven-dried biomass (B) were plotted with the help of Excel software. The pooled biomass and cover significance level was checked with the online p to n value calculator.

Results

In this study, 115 Quadrats were sampled in the entire campus of Banaras Hindu University from year 2019-2020. A total of 59 herbaceous species belonging to 28 families were recorded. Asteraceae was the most common family, while only single species represented the other 17 families. Among all the families, the three families (Poaceae, Fabaceae and Asteraceae) were most species-rich. Based on dry biomass (g $plant^{-1}$), *Peperomia pellucida*, *Nicotiana plumbaginifolia*, *Rungia pectinata*, *Parthenium hysterophorus*, *Oplismenus burmannii*, *Cynodon dactylon*, *Ruellia tuberosa*, and *Malvastrum coromandelianum* were dominant species in the study area. Total reported 59 Species showed a high range for percentage cover (1.16–30.45%) and biomass (1.42–173.3 g). *Tinospora cordifolia* and *Oplismenus burmannii* showed minimum (1.16) and maximum mean value (30.45%) for percentage cover, respectively. *T. cordifolia* and *P. pellucida* showed minimum (1.42) and maximum mean value (173.3 g) for biomass, respectively.

Various types of significant regression equations between cover (C) and biomass (B) of 59 herbaceous species are shown (Figs 1-6). All the species from Fig. 1 (A to J) to Fig. 3 (A to J) are showing linear regression equations for instance Dicanthium annulatum (Fig. 1. A), Sida acuta (Fig. 1. B), Ageratum conyzoides (Fig. 1. C), Malvestrum coromandelianum (Fig. 1. D), Oxalis corniculata (Fig. 1. E), Achyranthus aspera (Fig. 1. F), Evolvulus nummuralis (Fig. 1. G), Blumea tenella (Fig. 1. H), Cyperus brevifolius (Fig. 1. I) and Rungia pectinata (Fig. 1. J) whereas species like *Parthenium hysterophorus* (Fig. 5. A), *Alternenthera sessilis* (Fig. 5. E), *Oldenlendia corymbose* (Fig. 5. F) showed quadratic polynomial trendlines. *Zephyranthes citrina* (Fig. 4. C), *R. tuberosa* (Fig. 4. D), *Oplismenus burmannii* (Fig. 4. E), *Eragrostis tenella* (Fig. 4. F), *Abutilon indicum* (Fig. 4. G), *Gnaphalium indicum* (Fig. 4. H), *Sonchus oleraceus* (Fig. 4. I), and *N. plumbaginifolia* (Fig. 4. J) showed power regression equation. Only *A. paniculata* (Fig. 6. H), and *Chenopodium album* (Fig. 6. I) showed an exponential regression equation between cover and biomass. Among these significant equations, the considerable R^2 value (determination coefficient) varied from 0.38 (Polynomial equation) to 0.99 (Linear equation). In cases of the power equation, linear equation, polynomial and exponential equation, the maximum R^2 values were 0.95, 0.99, 1, and 0.93, respectively. Furthermore, minimum R^2 values were 0.42, 0.50, 0.38, and 0.56, respectively. The power regression equation was found between the pooled cover and pooled biomass of all the quadrats' herbaceous species *p-value* was also < .001.

Discussion

Biomass is an essential fundamental measurement in ecological study which refers to the total living biological material in a given area or of a biological community (Odum, 1971). Several studies have found that forage availability, carbon balance, and responses to global climate change can be addressed by spatial variations in biomass of the grassland ecosystems (Luo *et al.* 2002; Yahdjian and Sala, 2006). There is enough literature where a correlation between biomass and cover of the herbaceous species has been deduced where cover is a predictor of biomass (Jiang *et al*., 2017). According to Rottgermann *et al*. (2000), cover and biomass of a single plant species are linearly related. On the other hand, according to the niche complementarity, the complete utilization of available resources affect species richness which in turn leads to changes in species composition that potentially affects biomass cover relationship (Jiang *et al*., 2017; Rusch and Oesterheld, 1997; Caldeira *et al*., 2005). In our study, most species like *D. annulatum, Sida acuta, A. conyzoides*,

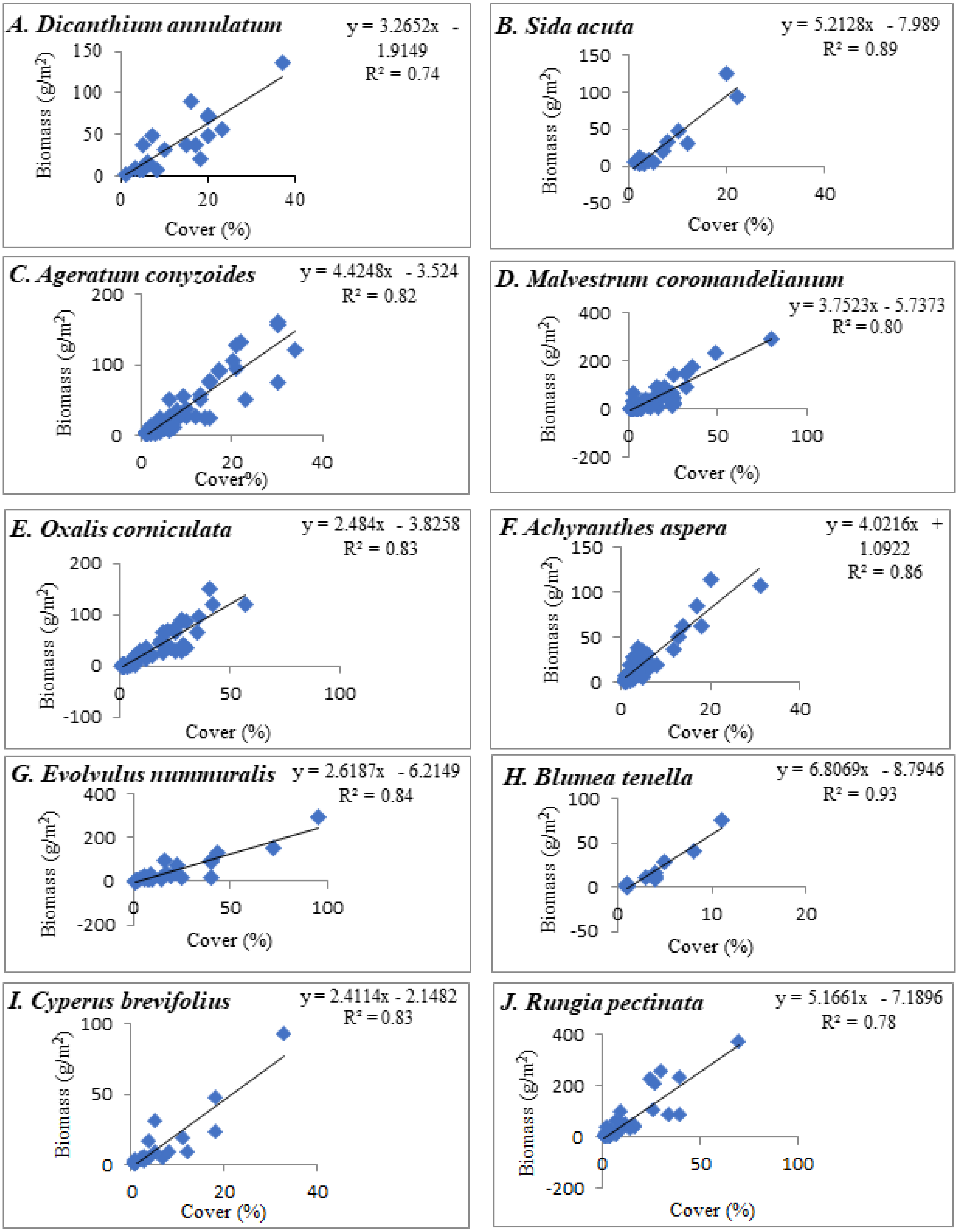

Fig.1: Graphs showing linear regression equation between percentage cover and herbaceous biomass of different species (A-J) in dry tropical grassland.

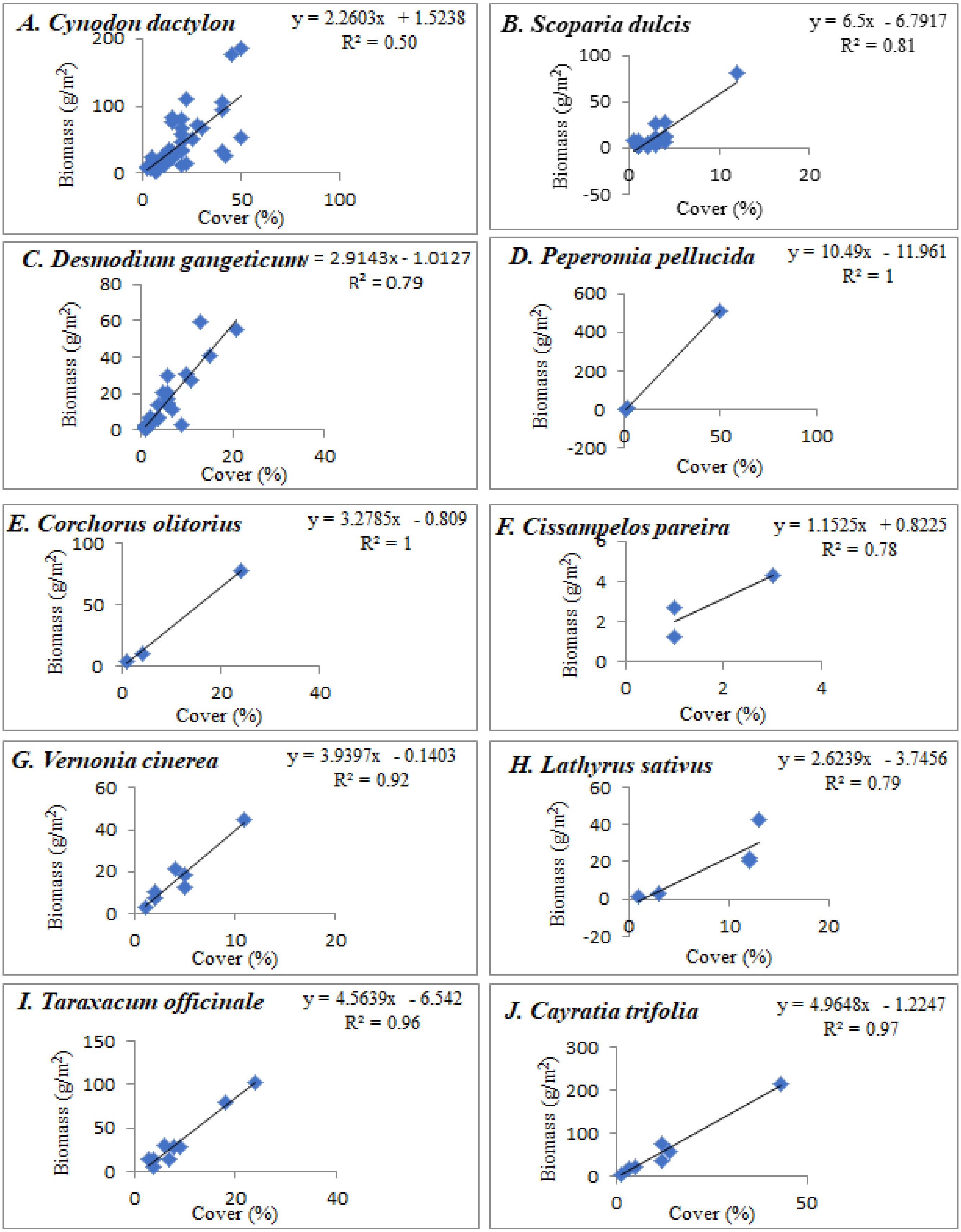

Fig. 2: Graphs showing linear regression equation between percentage cover and herbaceous biomass of different species (A-J) in dry tropical grassland.

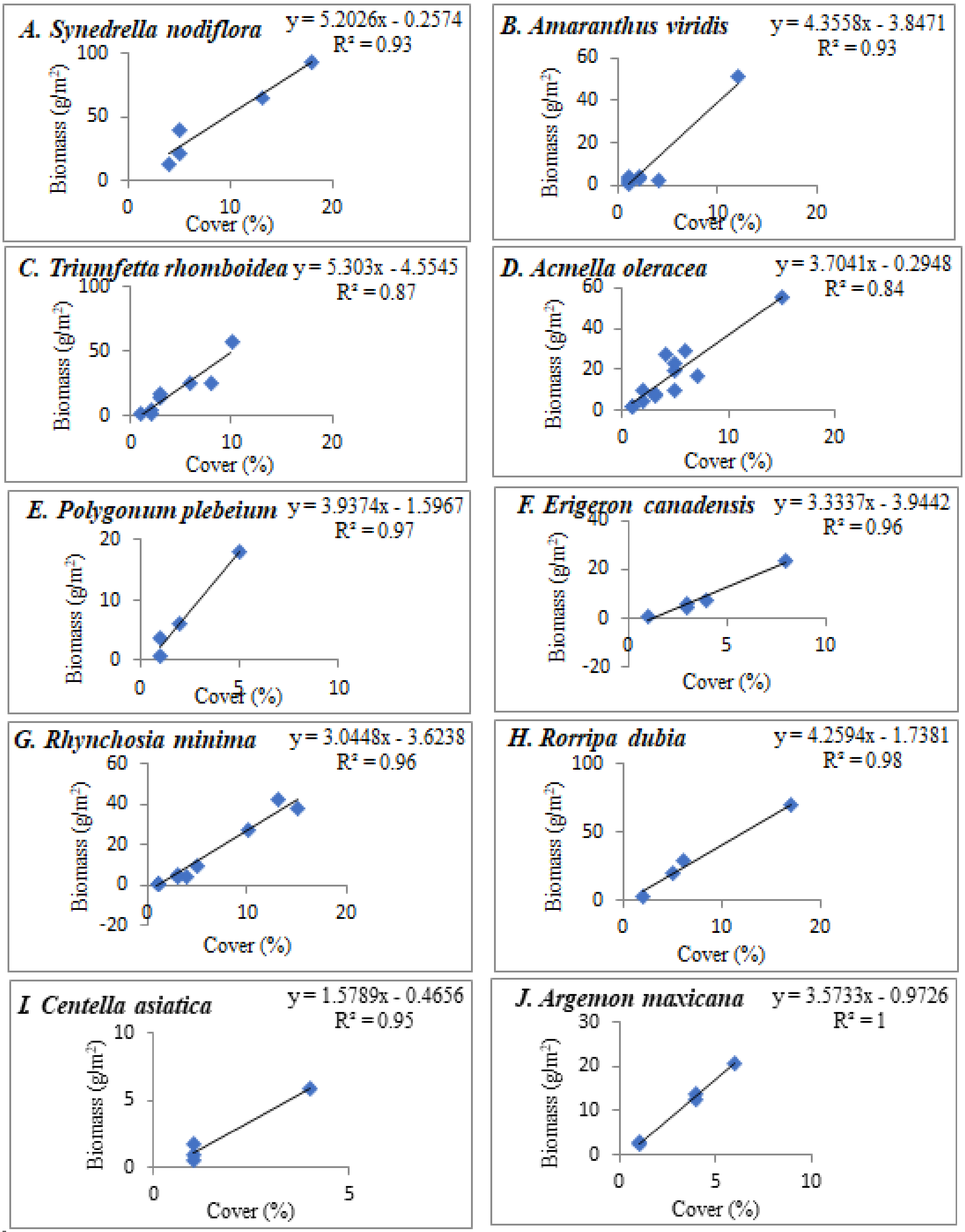

Fig. 3: Graphs showing linear regression equation between percentage cover and herbaceous biomass of different species (A-J) in dry tropical grassland**.**

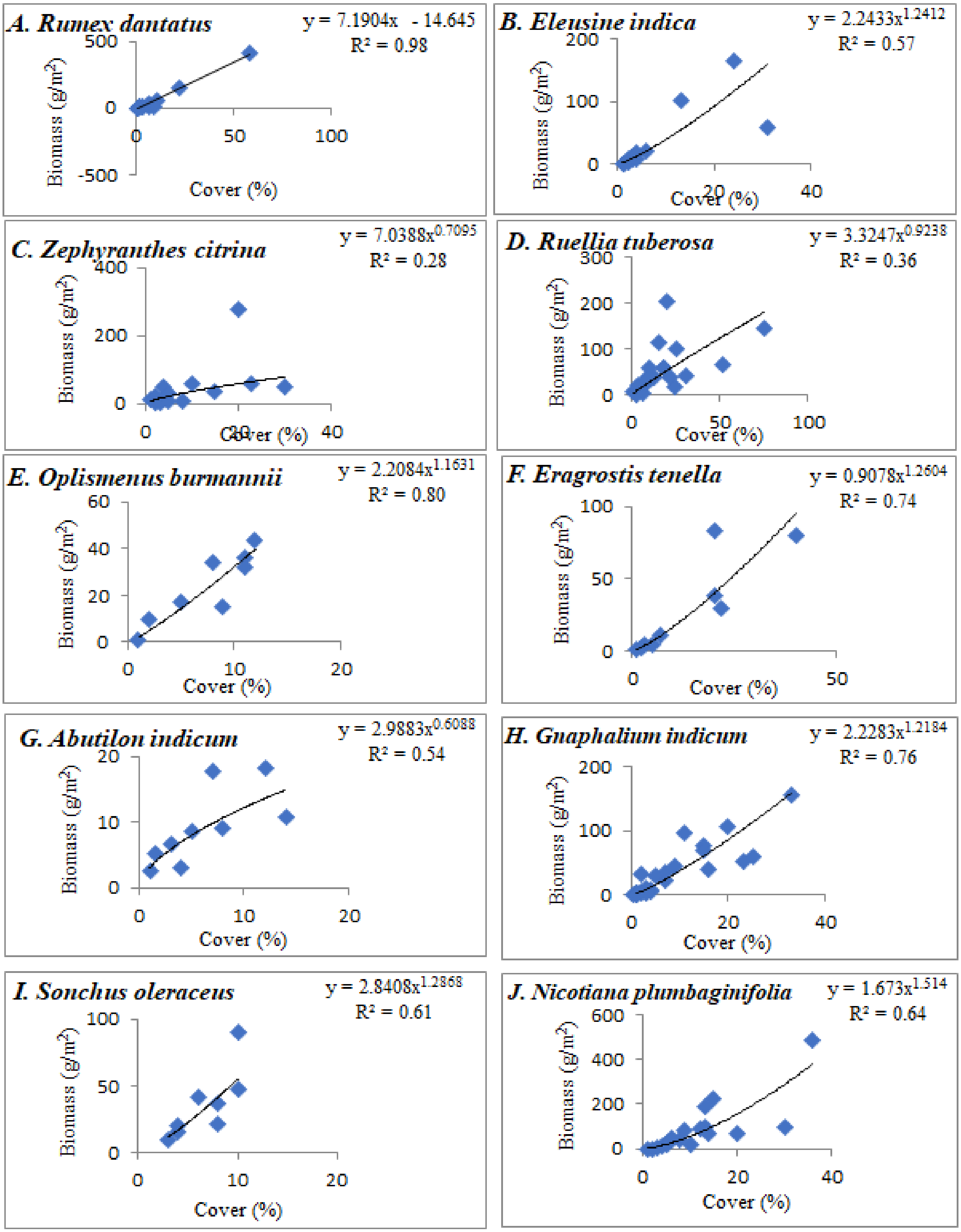

Fig. 4: Graphs showing linear (A) and power regression equation (B- J) between percentage cover and herbaceous biomass of different species in dry tropical grassland.

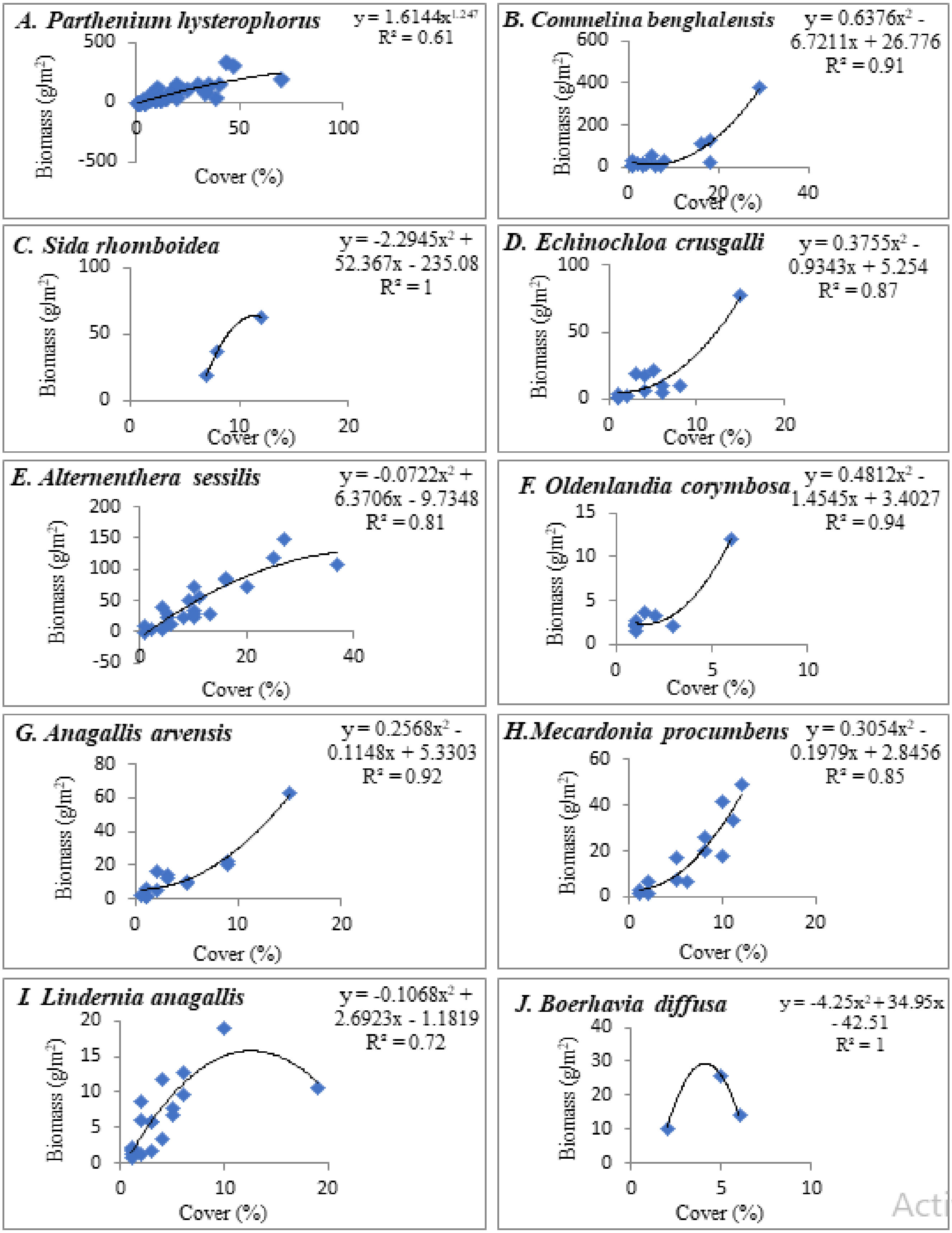

Fig. 5: Graphs showing polynomial regression equation between percentage cover and herbaceous biomass of different species (A-J) in dry tropical grassland.

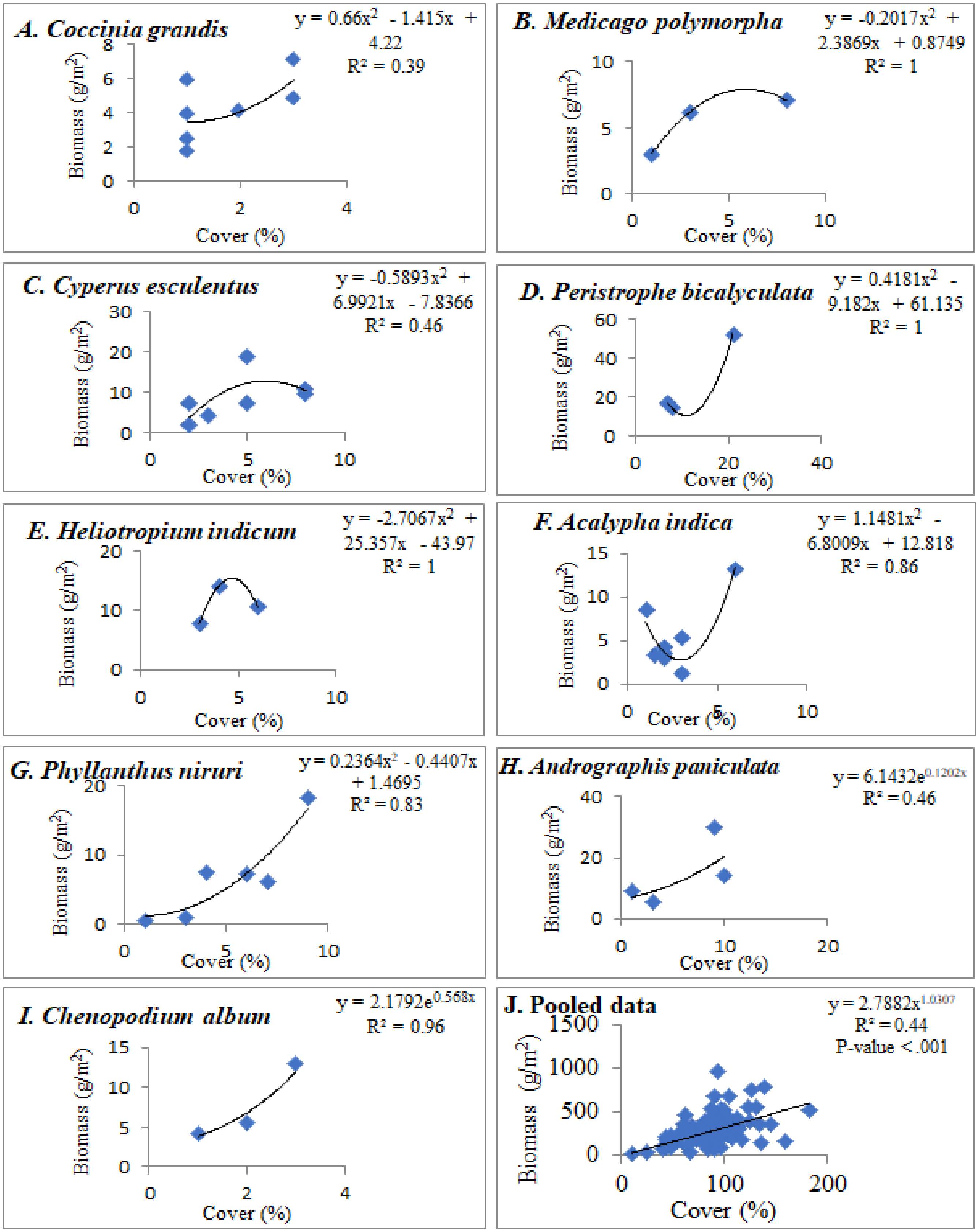

Fig. 6: Graphs showing polynomial(A-G), and exponential(H-I) regression equation between percentage cover and herbaceous biomass of different species (A-I), graph J is showing power regression equation between pooled biomass and cover of all the species in dry tropical grassland.

M. coromandelianum, *R. pectinate,* and *V. cinerea* showed linear, *P. hysterophorus, A. sessilis, B. diffusa* showed polynomial trendlines. Species like *Z. citrina* and *R. tuberosa* showed power regression equation, only *A. paniculata*, and *C. album* showed an exponential regression equation. The grassland ecosystem is affected by several biotic and abiotic stress, which affect type of vegetation, community structure, species richness, diversity, and community composition leading to different types of relationships between plant cover and biomass (Jiang. Y, 2017, Cantarel, Bloor, and Soussana, 2013). In our study the pooled cover and pooled biomass have shown the power regression equation with significant R^2 value at $p<0.001$. Very similar to some species of our study, the link between cover and above-ground biomass was not linear in an alpine ecosystem; several environmental conditions have a role in this relationship on a regional scale (Jiang *et al*., 2017).

Conclusion

The studied area's species composition shows large variability, leading to different types of relationships between percent cover and biomass. Various biotic and abiotic factors are responsible for the community structure and composition, which further determines the relationship between the percent cover and biomass of the area. The present study has given various significant regression equations between the percent cover and biomass of different species, which could be used in the non-destructive estimation of biomass of selected tropical grassland species. Using the regression equations, biomass of the listed species could be calculated easily without disturbing the vegetation of the study area, which will eventually help in the conservation of nature.

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Author's Contributions

Ram Sagar conceptualized the idea and designed the experiment. Alka Gupta and Aakansha Pandey performed the experiment and collected data. Alka Gupta analyzed the data. Alka Gupta and Aakansha Pandey drafted the manuscript and Ram Sagar corrected it. All the authors have critically read the drafted manuscript and approved it for publication.

Conflict Of Interest

The authors declare that they have no conflict of interest.

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