Evaluation of Forage Quality Indicators Using Multivariate Methods (Case Study: Rangelands of Karsanak, Chaharmahal va Bakhtiari Province)

Hassan Yeganeh
University of Tehran, Iran

Hossein Arzani
University of Tehran, Iran

Javad Motamedi
University of Urmia, Iran

Hamze Ali Shirmardi
Research Center for Agriculture and Natural Resources, Iran

Ehsan Zandi Esfahan
Research Institute of Forests and Rangelands, Iran

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Hassan Yeganeh [A], Hossein Arzani [A], Javad Motamedi [B], Hamze Ali Shirmardi [C] and Ehsan Zandi Esfahan [D]

[A] College of Natural Resources, the University of Tehran, Tehran, Iran
[B] College of Natural Resources, University of Urmia, Urmia, Iran
[C] Research Center for Agriculture and Natural Resources, Chaharmahal va Bakhtiari, Iran
[D] Rangeland Research Division, Research Institute of Forests and Rangelands, Tehran, Iran
Contact email: hyeganeh@ut.ac.ir

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Introduction

In most studies on forage quality, the rank of species and the interaction effect between species and time (grazing months) has not been analyzed for forage quality (Meshkani 1986). An additive main effect and multiplicative interaction (AMMI) model is able to analyse the interaction of species in the environment. Studies on stability of forage production have been carried out using the AMMI model (Farshadfar *et al*. 2010).

The objective of the current research was to determine the forage quality indicators of range species through AMMI models in semi-steppe rangelands of Karsanak area of Iran.

Methods

In the current study, 10 important and palatable range species were sampled from Karsanak region of Iran at three phenological stages - vegetative, flowering and maturity. All samples were chemically analyzed to measure the percentage of nitrogen (N) and acid detergent fiber (ADF) using formula suggested by Fonnesbeck *et al.* (1984). A factorial experiment was applied based upon a completely randomized design to analyze the additive effects of data. The AMMI model was used for analysis of multiplicative effects (interaction effect of species by stage). Biplot graphs were used to evaluate the stability of the species, phenological stages and also to determine the relationship between species and different phenological stages. In the AMMI model, Analysis of Variance and the main components are combined in a single analysis (Gauch 1992).

Results

The main effects and interactions of species and phenological stage on forage quality indicators were significant. Means comparisons for forage quality of species using Duncan's test at the 1% significance level are presented in Table 1.

According to the AMMI model of forage quality at different stages (Table 2), additive effects of species and stage were significant at 1% probability level with 90% of total sum of squares. In the AMMI model, interaction effect of stage by species was significant at P<0.01 and sum of squares of the interaction effect were divided to two components in which the first interaction principal component (IPCA1) was significant for all indicators at 1% probability level. The second interaction principal component (IPCA2) was also significant at 1% level.

With regard to the pattern of the responses of the species based upon IPCA1and the recorded averages, species of *P. olivieri*, *A. molluginoides*, *S. lavandulifolia*, *P persica*, *A. effusus* and *T. elliptica* showed the lowest interaction effect of species by environment (Fig. 1). Among the species, *A. effusus* and *T. elliptica* with an IPCA close to zero and a protein content (CP) higher than total average were introduced as the most stable species. Species of *A. ovinus* and *A. brachystachys* and initial growth stage were similarly marked and produced positive interaction effects.

Table 1. Comparison of forage quality of species.

Species	CP	ADF	DDM	ME
Achillea santolina	11.32±0.44e	32.98±0.69d	61.17±0.74c	8.40±0.13c
Astragalus brachystachys	21.98±0.81a	23.91±0.86f	73.11±1.04a	10.43±0.18a
Astragalus effusus	19.99±0.56b	35.68±0.70c	62.58±0.80c	8.64±0.14c
Asperula molluginoides	13.05±0.66d	45.73±1.73a	51.38±1.69e	6.73±0.29e
Astragalus ovinus	17.42±1.01c	23.33±0.64f	71.67±0.95a	10.18±0.16a
Onobrychis gaubae	17.47±0.30c	29.47±0.37e	66.64±0.42b	9.33±0.07b
Phlomis olivieri	13.67±0.74d	40.88±0.89b	55.64±1.03d	7.46±0.17d
Phlomis persica	13.34±0.62d	38.30±0.76cb	57.63±0.88e	7.80±0.15d
Stachys lavandulifolia	14.17±0.61d	32.23±0.40ed	62.97±0.58c	8.71±0.10c
Trigonella elliptica	18.35±0.74c	30.90±1.11ed	65.83±1.22b	9.19±0.21b

Means in a column with different superscripts (a, b, c, d, e, f) are different (P<0.05).

Table 2. Mean squares from analysis of variance for forage quality characteristics with AMMI model.

Sources of variation	DF	ADF		ME		DMD		CP	
		MS	SS%	MS	SS%	MS	SS%	MS	SS%
Species	9	86.**451	78.43	14.**12	75.34	1.**420	7.34	7.**107	8.22
stage	2	92.**2154	31.41	14.**84	53.53	8.**2913	5.53	3.**1402	05.66
Stage by species	18	84.**54	03.10	37.**1	87.7	5.**47	8.7	2.**20	57.8
IPCA1	10	48.**90	66.91	28.**2	46.92	1.**79	5.92	5.**29	2.81
IPCA2	8	29.10ns	34.8	23.0ns	54.7	06. 8ns	5.7	5.**8	8.18
Error	60	02.8	89.4	2.0	86.3	7	8.3	8.1	5.2

*P<0.05,**P<0.01,NS:Non-significant.

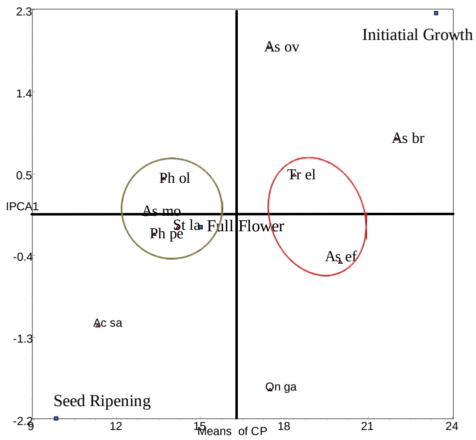

Figure 1. The biplot of the first interaction principal component and average CP.

Conclusions

In general, *A. brachystachys* and *A. ovinus* are introduced as the most stable species on the basis of of DMD, ME and ADF. Therefore, it can be inferred that the mentioned species in addition to high stability have high forage quality indices. According to the results of additive (ANOVA and Duncan test) and multiplicative analyses, *A. brachystachys* and *A. ovinus* were identified as the most stable species; therefore in grazing management plan, more stability can be considered in calculating grazing capacity for these species. Results also indicated that the AMMI model showed good potential for identifying the stability of forage quality indices and compared to other methods it was more effective in determining highly stable species with high forage quality under multiple environmental experiments.

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