Biological Forum – An International Journal **14(3): 829-833(2022)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Character Association and Path coefficient Analysis among Diverse Genotypes of Forage Maize (*Zea mays* L.)

Tejaskumar H. Borkhatariya[1], Dipakkumar P. Gohil[2], Praful M. Sondarava[1], Rumit Patel[3] and Kuldeep M. Akbari[1]*
[1]M.Sc. (Agri.), Department of Genetics and Plant Breeding, B.A. College of Agriculture, AAU, Anand (Gujarat), India.
[2]Research Scientist & Head, Main Forage Research Station, AAU, Anand, (Gujarat), India.
[3]Research Associate, Department of Agricultural Biotechnology, AAU, Anand (Gujarat), India.

(Corresponding author: Tejaskumar H. Borkhatariya)*
(Received 29 May 2022, Accepted 28 July, 2022)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Forage crops are highly important, especially for the countries like India which has a large livestock population. Therefore in the present investigation,fifty elite genotypes of forage maize (*Zea mays* L.) were evaluated for the study of character association and path coefficient analysis during *Kharif*-2021 at Main Forage Research Station, AAU, Gujarat, India. Results revealed that days to 50% tasseling, days to 50% silking, number of leaves per plant, plant height, stem thickness, leaf length, leaf width, leaf: stem ratio and dry matter content had a significantly positive correlation with green fodder yield at both genotypic as well as phenotypic level. The highest correlation of plant height (r_g = 1.043) and stem thickness (r_p = 0.819) with green fodder yield was found at genotypic and phenotypic levels, respectively. The path coefficient analysis revealed positive direct effects of such yield contributing traits, like days to 50% tasseling, days to 50% silking, number of leaves, stem thickness, leaf length, dry matter content and crude protein content. The highest positive direct effect was observed from leaf length. Therefore, selecting the plant with more number of leaves, higher leaf length and good stem thickness will ultimately increase the green fodder yield.

Keywords: Forage maize, Character association, Path analysis, Correlation coefficient, Fodder quality.

INTRODUCTION

India is ranked first in milk production contributing 23% of the global milk production. Milk production in the country has grown at a compound annual growth rate of about 6.2% to reach 209.96 million metric tonnes in 2020-21 from 146.31 million tonnes in 2014-15 (Economic survey, 2022). Milk production is heavily reliant on the availability of high-quality fodder. Also, an insufficient supply of high-quality feed and fodder is the primary factor lowering milch animal productivity in India (Kumari *et al*., 2022). On all India basis, there is an overall deficit of 11.24% in green fodder availability in the country. Total green fodder availability is 734.2 million metric tonnes against the requirement of 827.19 million metric tonnes. The major source of green fodder in India is cultivated land, followed by pasture land and forests (Roy *et al*., 2019). To meet the needs of an ever-increasing livestock population, fodder production and productivity must be increased.

Maize (*Zea mays* L.) is a dual-purpose crop that produces kernels for human consumption as well as fodder for livestock. It is an excellent source of animal feed due to its high content of protein, good palatability and good digestibility (Ballard *et al*., 2001). Forage maize also holds sufficient nutritional quality when we compare it to other non-leguminous fodders (Mahdi *et al*., 2011).Identifying the genetic compositions that are superior in green fodder yield is the main problem faced by forage maize breeders. Green fodder yield is influenced by various metric traits and it is the consequence of numerous complex morphological and physiological processes that take place at different stages of growth. To select better genotypes with higher green fodder yield and good nutritional quality, it is critical to understand how these economically beneficial traits are related to other characteristics. Correlation analysis identifies relationships between different agronomical qualitative traits in genetically diverse populations for crop improvement (Silva *et al*., 2016).

While going for selection in forage crops, a breeder must know about the direction and magnitude of the association between the forage yield and its contributing traits. Correlation measures the extent and direction (positive or negative) of the relationship between two or more variables, while path analysis partitions correlations into direct and indirect effects. The estimates of correlation and path coefficients help breeders to understand the roles and relative contributions of various traits in determining the growth behaviour of crop cultivars under specific environmental conditions (Shahbaz *et al*., 2007). The aim of this study was to determine the relationships between various forage maize characters and to identify the direct and indirect effects of yield contributing characters on green fodder yield.

MATERIAL AND METHODS

Experimental site. The experiment was conducted during *Kharif*-2021 at Main Forage Research Station, Anand Agricultural University, Anand (22° 35' N, 72° 55' E), Gujarat, India. The soil texture of the experimental location at Anand centre is sandy loam, with a pH range of 8.1 to 8.5. It has low organic matter, nitrogen and cation exchange capacity, while it has a medium phosphorus content and it is moderately rich in potash.

Experimental design and material. Fifty diverse forage maize genotypes were evaluated in a randomized complete block design with three replications. Each genotype was planted in a single row of 5.0 m in length, 30 cm apart, with a 10 cm plant-to-plant spacing. To avoid damage and border effects, the experiment was surrounded by border rows. The recommended agronomical and plant protection practices were followed for the successful raising of the crop.

Observations recorded and characters investigated. Observations were recorded on five randomly selected plants from each entry for thirteen different traits *viz*., days to 50% tasseling, days to 50% silking, number of leaves per plant, plant height (cm), stem thickness (cm), leaf length (cm), leaf width (cm), leaf: stem ratio, dry matter content (%), crude protein content (%)[CP], neutral detergent fibre content (%)[NDF], acid detergent fibre content (%)[ADF]and green fodder yield per plant (g). The sample collected from each genotype was chopped and air-dried for three days followed by oven drying at 100º C till the attainment of constant weight and then dry matter content was calculated from the data. After that, the sample was powdered and scanned with "FOSS NIR System" (Model: 5000 composite) following the standard analytical protocol to estimate all the quality parameters such as CP, NDF and ADF.

Statistical analysis. The data collected were analysed for correlation and path coefficient study. Genotypic and phenotypic coefficients of correlation were calculated from genotypic and phenotypic co-variances and variances as described by Singh and Chaudhry (1985); Johnson *et al.* (1955). Direct and indirect effects were calculated by the path coefficient analysis as suggested by Dewey and Lu (1959) at both phenotypic and genotypic levels. The data were analysed using the "Variability" package (Popat *et al*., 2020) in the R-studio.

RESULTS AND DISCUSSION

Fodder yield is a complex character that is influenced by a number of other traits, each of which has either a positive or negative association with green fodder yield, with direct as well as indirect effects. It is important to remember that whenever two traits are correlated, selecting for one trait would ensure selection for the other automatically. As a result, choosing the best traits in this study that correlated with yield would lead to a higher yield in forage maize. Determining appropriate selection methods for the yield components requires knowledge of the mechanisms of association, causes and effects relationships, which forms the basis for achieving rational improvement in fodder yield and its components.

Association between forage traits. The genotypic correlation coefficients and phenotypic correlation coefficients for various traits are given in Tables 1 and 2, respectively. Results indicated that all the traits, except CP and ADF, had a positive and significant correlation at the genotypic level with green fodder yield per plant. CP and ADF also had a significant, but negative genotypic correlation with green fodder yield. Earlier negative genotypic correlation for ADF content in forage maize was found by Kapoor and Batra (2015). While at the phenotypic level, all the traits, except three quality traits *viz*., CP, NDF and ADF; were found positively and significantly correlated with green fodder yield per plant. Thus, selection based on these traits will result in improving the green fodder yield in forage maize genotypes. These results were in harmony with the findings of Kapoor and Batra (2015) as well as Rathod *et al*. (2021) for number of leaves, plant height, stem girth, leaf length and leaf width. Kapoor and Batra (2015) as well as Naharudin *et al*. (2021), also observed non-significant phenotypic correlations for quality parameters, which was in accordance with the present investigation.

The genotypic as well as phenotypic correlation coefficients among various yield component traits *viz.*, days to 50% tasseling, days to 50% silking, number of leaves per plant, plant height, stem thickness, leaf length and leaf width were significantly positive. Crude protein content was found negative but significantly correlated with all the characters except with leaf: stem ratio at the genotypic level. Also, acid detergent fibre content had a negative and significant genotypic correlation with most of the traits, except dry matter content and neutral detergent fibre content.

Table 1: Genotypic correlation coefficients among various traits of forage maize genotypes.

	DS	NOL	PH	ST	LL	LW	LSR	DM	CP	NDF	ADF	GFYPP
DT	0.955**	0.593**	1.003**	0.907**	0.835**	0.913**	0.354*	0.139	-0.496**	-0.262	-0.894**	0.892**
DS		0.565**	0.968**	0.880**	0.802**	0.855**	0.336*	0.225	-0.695**	0.053	-0.684**	0.901**
NOL			0.649**	0.733**	0.357*	0.632**	0.127	0.101	-0.498**	-0.027	-2.183**	0.599**
PH				1.044**	0.934**	0.945**	0.164	0.198	-0.926**	0.514**	-1.998**	1.043**
ST					0.813**	0.847**	0.182	0.217	-0.570**	0.315*	-1.839**	0.941**
LL						0.914**	0.119	0.125	-0.433**	0.209	-2.084**	0.828**
LW							0.204	0.187	-0.399**	0.303*	-0.828**	0.887**
LSR								-0.071	0.142	-0.229	-1.394**	0.282*
DM									-1.081**	2.484**	3.919**	0.351*
CP										-2.021**	-2.788**	-0.674**
NDF											7.999**	0.638**
ADF												-0.401**

*, **Significant at 5% and 1% level of significance; DT= days to 50% tasseling, DS= days to 50% silking, NOL= number of leaves per plant, PH= plant height (cm), ST= stem thickness (cm), LL = leaf length (cm), LW= leaf width (cm), LSR: leaf: stem ratio, DM= dry matter content (%), CP= crude protein content (%), NDF= neutral detergent fibre content (%), ADF= acid detergent fibre content (%), GFYPP= green fodder yield per plant (g)

Table 2: Phenotypic correlation coefficients among various traits of forage maize genotypes.

	DS	NOL	PH	ST	LL	LW	LSR	DM	CP	NDF	ADF	GFYPP
DT	0.929**	0.435**	0.620**	0.644**	0.650**	0.699**	0.258**	0.110	-0.149	-0.001	-0.085	0.801**
DS		0.406**	0.615**	0.639**	0.623**	0.648**	0.261**	0.175*	-0.199*	0.026	-0.072	0.802**
NOL			0.501**	0.498**	0.269**	0.396**	0.079	0.024	-0.036	-0.076	-0.058	0.477**
PH				0.747**	0.675**	0.609**	0.146	0.134	-0.037	0.003	0.014	0.781**
ST					0.711**	0.704**	0.177*	0.054	-0.032	-0.034	-0.071	0.819**
LL						0.719**	0.161*	0.058	0.002	-0.054	-0.055	0.735**
LW							0.200*	0.140	-0.109	-0.001	-0.071	0.739**
LSR								-0.031	0.084	-0.079	-0.080	0.240**
DM									-0.419**	0.492**	0.313**	0.188*
CP										-0.392**	-0.272**	-0.140
NDF											0.268**	0.066
ADF												0.019

*, **Significant at 5% and 1% level of significance; DT= days to 50% tasseling, DS= days to 50% silking, NOL= number of leaves per plant, PH= plant height (cm), ST= stem thickness (cm), LL = leaf length (cm), LW= leaf width (cm), LSR: leaf: stem ratio, DM= dry matter content (%), CP= crude protein content (%), NDF= neutral detergent fibre content (%), ADF= acid detergent fibre content (%), GFYPP= green fodder yield per plant (g)

The maximum positive genotypic correlation coefficient was observed between NDF and ADF (r_g = 7.999), followed by dry matter content and ADF (r_g = 3.919). While the highest negative and significant correlation coefficient was found between CP and ADF (r_g = –2.788), followed by number of leaves per plant and ADF (r_g = –2.183). The highest value of positive and significant phenotypic correlation was observed between days to 50% tasseling and days to 50% silking (r_p = 0.929), followed by stem thickness and green fodder yield per plant (r_p = 0.819). Whereas dry matter content and CP (r_p = –0.419) exhibited the highest value of negative and significant correlation at the phenotypic level, followed by CP and NDF (r_p = –0.392).

The highest correlation of plant height (r_g = 1.043) and stem thickness (r_p = 0.819) with green fodder yield per plant was found at genotypic and phenotypic levels, respectively. While the highest negative correlation of green fodder yield per plant was observed with crude protein content (r_g = –0.674, r_p = –0.140).Significant correlations between fodder yield as well as various yield contributing traits suggest that these characteristics were controlled by genes with pleiotropic effect or controlled by multiple genes that are linked (Chen and Lubberstedt 2010).

Path coefficient analysis. The partitioning of the total correlation coefficient into direct and indirect effects for green fodder yield revealed positive direct effects of many yield contributing traits, like days to 50% tasseling (2.3479), days to 50% silking (0.8148), number of leaves (1.5062), stem thickness (0.6432), leaf length (3.5755), dry matter content (2.1036) and crude protein content (0.7623) [Table 3]. Similarly, the positive direct effect of days to 50% tasseling was found by Rathod *et al*. (2021). While, Kapoor and Batra (2015) as well as Kapoor (2017) for number of leaves; Kapoor and Batra (2015); Kapoor (2017); Rathod *et al.* (2021) for stem girth; Kapoor (2017); Rathod *et al.* (2021) for leaf length; Rathod *et al.* (2021) for dry matter content; observed positive direct effects. Thus, the improvement in yield contributing characteristics such as number of leaves, stem thickness and leaf length will help to improve green fodder yield directly as well as indirectly.

Table 3: Path coefficient analysis for direct (bold) and indirect effects on green fodder yield per plant (g) in for forage maize genotypes.

	DT	DS	NOL	PH	ST	LL	LW	LSR	DM	CP	NDF	ADF	Genotypic correlation with GFYPP
DT	**2.3479**	0.7784	0.8936	-3.5218	0.5832	2.9866	-3.0698	-0.1364	0.2917	-0.3771	0.0733	0.0424	0.892**
DS	2.2430	**0.8148**	0.8507	-3.3979	0.5661	2.8682	-2.8768	-0.1295	0.4731	-0.5286	-0.0149	0.0324	0.901**
NOL	1.3930	0.4602	**1.5062**	-2.2793	0.4717	1.2762	-2.1231	-0.0489	0.2118	-0.3789	0.0074	0.1035	0.599**
PH	2.3559	0.7888	0.9781	**-3.5099**	0.6712	3.3380	-3.1793	-0.0632	0.4162	-0.7035	-0.1438	0.0947	1.043**
ST	2.1288	0.7172	1.1044	-3.6626	**0.6432**	2.9061	-2.8476	-0.0701	0.4572	-0.4346	-0.0882	0.0872	0.941**
LL	1.9612	0.6536	0.5376	-3.2768	0.5228	**3.5755**	-3.0736	-0.0459	0.2626	-0.3289	-0.0587	0.0988	0.828**
LW	2.1427	0.6969	0.9506	-3.3173	0.5445	3.2670	**-3.3638**	-0.0784	0.3937	-0.3030	-0.0847	0.0393	0.887**
LSR	0.8313	0.2739	0.1912	-0.5759	0.1170	0.4261	-0.6842	**-0.3853**	-0.1500	0.1076	0.0642	0.0661	0.282*
DM	0.3256	0.1833	0.1516	-0.6944	0.1398	0.4463	-0.6295	0.0275	**2.1036**	-0.8216	-0.6952	-0.1858	0.351*
CP	-1.1615	-0.5650	-0.7487	3.2392	-0.3667	-1.5427	1.3370	-0.0544	-2.2672	**0.7623**	0.5641	0.1318	-0.674**
NDF	-0.6147	0.0435	-0.0400	-1.8028	0.2027	0.7495	-1.0178	0.0884	5.2247	-1.5364	**-0.2799**	-0.3793	0.638**
ADF	-2.0989	-0.5575	-3.2879	7.0137	-1.1827	-7.4506	2.7862	0.5368	8.2448	-2.1183	-2.2391	**-0.0474**	-0.401**

*, **Significant at 5% and 1% level of significance; DT= days to 50% tasseling, DS= days to 50% silking, NOL= number of leaves per plant, PH= plant height (cm), ST= stem thickness (cm), LL = leaf length (cm), LW= leaf width (cm), LSR: leaf: stem ratio, DM= dry matter content (%), CP= crude protein content (%), NDF= neutral detergent fibre content (%), ADF= acid detergent fibre content (%), GFYPP= green fodder yield per plant (g).

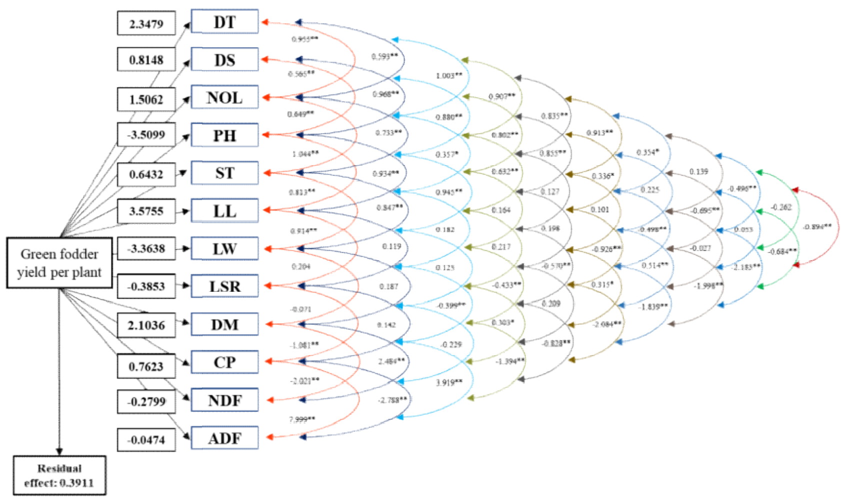

Fig. 1. Path diagram depicting genotypic correlation and direct effects of yield attributes on green fodder yield per plant in forage maize [*, **Significant at 5% and 1% level of significance; DT= days to 50% tasseling, DS= days to 50% silking, NOL= number of leaves per plant, PH= plant height (cm), ST= stem thickness (cm), LL = leaf length (cm), LW= leaf width (cm), LSR: leaf: stem ratio, DM= dry matter content (%), CP= crude protein content (%), NDF= neutral detergent fibre content (%), ADF= acid detergent fibre content (%), GFYPP= green fodder yield per plant (g)].

However, negative direct effects were observed for such traits as plant height (-3.5099), leaf width (-3.3638), leaf: stem ratio (-0.3853), NDF (-0.2799) and ADF (-0.0474). It ultimately indicated that the positive significant correlation of most of these traits with green fodder yield per plant was due to indirect effects generated through other characters mainly. The negative direct effect of leaf width and leaf: stem ratio was observed by Kapoor (2017), also Kapoor and Batra (2015) reported a negative direct effect of ADF on green fodder yield.

The highest positive direct effect on green fodder yield per plant was observed from leaf length followed by days to 50% tasseling and dry matter content. Although plant height had the highest negative direct effect, the positive correlation with green fodder yield was due to the positive indirect effects via leaf length and other important traits.

Further, days to 50% tasseling, days to 50% silking, number of leaves per plant, stem thickness, leaf length and dry matter content had a true relationship with green fodder yield per plant by establishing a significant positive association and positive direct effect on green fodder yield. Thus, selection for these traits will be more rewarding for the improvement of green fodder yield per plant in forage maize.

CONCLUSION

Results of the present investigation lead to the conclusion that selection for the traits like days to 50% tasseling, days to 50% silking, number of leaves per plant, plant height, stem thickness, leaf length, leaf width, leaf: stem ratio and dry matter content could improve green fodder yield as they had a positive correlation. As per path analysis, selection for the plant with more number of leaves, higher leaf length and good stem thickness will efficiently increase the green fodder yield. At the same time selection for higher crude protein content and acid detergent fibre content can adversely affect the progress in breeding for improving green fodder yield due to the strong negative association of these traits with it. However, balancing different quality parameters is also an important task while practising the selection for various quantitative traits to improve green fodder yield in forage maize. Overall, selection for the plant height in forage maize can lead to higher production of green fodder as it had the highest positive correlation with it.

FUTURE SCOPE

The current investigation provided information regarding the association between different traits in forage maize and the combination of the various characteristics investigated can be further used in the breeding programme to develop elite genotypes of forage maize with higher production of green fodder. The selection for those particular traits identified with a positive effect on yield can directly or indirectly be helpful in improving the fodder production in maize.

Acknowledgement. I extend my sincere thanks to Dr. D. P. Gohil (major advisor) and to my advisory committee members for giving me proper guidance throughout the course of the study. I also sincerely thank Anand Agricultural University for providing the necessary resources for the present study.

Conflict of Interest: None.

REFERENCES

Ballard, C. S., Thomas, E. D., Tsang, D. S., Mandebvu, P., Sniffen, C. J., Endres, M. I. & Carter, M. P. (2001). Effect of corn silage hybrid on dry matter yield, nutrient composition, *in vitro* digestion, intake by dairy heifers, and milk production by dairy cows. *Journal of Dairy Science*, *84*(2): 442-452.

Chen, Y., & Lubberstedt, T. (2010). Molecular basis of trait correlation. *Trends in Plant Science*, *15*(8): 454-461.

Dewey, D. R., & Lu, K. (1959). A correlation and path coefficient analysis of components of crested wheatgrass seed production. *Agronomy Journal*, *51*(9): 515-518.

Economic survey (2022). Retrieved from https://www.indiabudget.gov.in/economicsurvey/ebook_es2022/files/basic-html/page277.html

Johnson, H. W., Robinson, H. F., & Comstock, R. E. (1955). Estimates of genetic and environmental variability in soybeans. *Agronomy Journal*, *47*(7): 314-318.

Kapoor, R. (2017). Variability and character association studies in fodder maize (*Zea mays* L.) hybrids. *Forage Research*, *43*(1): 67-69.

Kapoor, R., & Batra, C. (2015). Genetic variability and association studies in maize (*Zea mays* L.) for green fodder yield and quality traits. *Electronic Journal of plant breeding*, *6*(1): 233-240.

Kumari, J., Sood, V. K., Mishra, P., Kumar, S., Sanadya, S., & Sharma, G. (2022). Genetic Variability and Association Analysis for some Forage and Seed yield Related Traits in $F_4$and F_5Generations of Oat (*Avena sativa* L.). *Biological Forum – An International Journal*, *14*(2): 1-9.

Mahdi, S. S., Badrul, H., Bhat, R. A., Aziz, M. A., Lal, L., Intikhab, A., & Shibana, B. (2011). Effect of nitrogen, zinc and seed rate on growth dynamics and yield of fodder maize (*Zea mays* L.) under temperate conditions. *Plant Archives*, *11*(2): 965-971.

Naharudin, N. S., Sin, M. A., & Saleh, G. (2021). Genetic Variance and Correlation of Forage Yield and Quality Traits in Tropically Adapted Maize. *Sains Malaysiana*, *50*(1): 45-52.

Popat, R., Patel, R. & Parmar, D. (2020). Variability: Genetic Variability Analysis for Plant Breeding Research, https://cran.r-project.org/web/packages/variability/variability.pdf

Rathod, S. D., Shinde, G. C., & Shinde, S. D. (2021). Genetic variability and path coefficient analysis studies in forage maize genotypes (*Zea mays* L.). *Journal of Pharmacognosy and Phytochemistry*, *10*(1): 2764-2768.

Roy, A., Agarwal, R., Bhardwaj, N., Mishra, A., & Mahanta, S. K. (2019). Revisiting National Forage Demand and Availability Scenario. In: *Indian Fodder Scenario: Redefining State Wise Status* (Eds. Roy, A. K., Agrawal, R. K., & Bhardwaj, N. R.). ICAR- AICRP on Forage Crops and Utilization, Jhansi, India, p. 1-21.

Shahbaz, A., Oki, M. Y., & Adachi, T. (2007). Path and correlation analyses of the factors affecting biomass production of brassica cultivars under phosphorus-deficiency stress environment. *Communications in Soil Science and Plant Analysis, 38*(19-20): 2659-2679.

Silva, T. N., Moro, G.V., Moro, F.V., Santos, D. M. M. D., & Buzinaro, R. (2016). Correlation and path analysis of agronomic and morphological traits in maize. *Revista Ciencia Agronomica*, *47*(2): 351-357.

Singh, R. K., & Chaudhary, B. D. (1985). *Biometrical methods in quantitative genetic analysis*.Kalyani publishers, New Delhi, India.

How to cite this article: Tejaskumar H. Borkhatariya, Dipakkumar P. Gohil, Praful M. Sondarava, Rumit Patel and Kuldeep M. Akbari (2022). Character Association and Path coefficient Analysis among Diverse Genotypes of Forage Maize (*Zea mays* L.). *Biological Forum – An International Journal*, *14*(3): 829-833.