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Relationship between plant signs and consumer decisions

Über den Zusammenhang zwischen Pflanzenmerkmalen und Verbraucherentscheidungen

Detlev Reymann and Jan Benninga
(Fachbereich Gartenbau und Landespflege der Fachhochschule Wiesbaden and Proefstation voor Bloemisterij en Glasgroente Aalsmeer)

Summary

A survey with 247 customers was carried out in four german horticultural shops to identify the relationship between plant signs and consumer preferences. Objective were poinsettia plants. Approximatly 50 to 60 percent of the variance could be explained by the plant signs included into regression analysis and 70 % with the two main components of a principal component analysis. For each of the shops where the survey took place different plant signs were identified as relevant. The results show that it is not possible to explain customer decisions by using a simple additive approach where the final decision is seen as the result of the addition of partial decisions. But the combination of principal component analysis and regression analysis may help to show which plants signs are most important for growers to satisfy customers needs. Also it seems to be neccesary to record the customer rankings not only as scalar values. Confrontation of PCA-results with the results of multiple regression points out that using multiple regression has limited validity in this kind of experiments if there are variables with large ranges and intercorrelations.

Zusammenfassung

Im Rahmen einer Befragung von 247 Kunden in vier verschiedenen deutschen Gärtnereien wurde der Zusammenhang zwischen Pflanzenmerkmalen und den Kaufentscheidungen von Konsumenten am Beispiel des Weihnachtssternes untersucht. Objektiv messbare Merkmale erklären im Ergebnis von Regressionsanalysen im Durchschnitt 50 bis 60 Prozent der erfassten Varianz und etwa 70 Prozent der Varianz durch die beiden wichtigsten Komponenten einer Hauptkomponentenanalyse. Zudem werden in den verschiedenen Befragungsorten unterschiedliche Eigenschaften als relevant identifiziert. Die Ergebnisse der Untersuchung deuten darauf hin, dass Konsumentenentscheidungen nicht als einfacher additiver Prozess zu erklären sind. Die Kombination von Hauptkomponenten- und Regressionsanalysen kann Hinweise geben, welche Pflanzenmerkmale aus Sicht der Kunden besonders wichtig sind. Die Untersuchung legt den Schluss nahe, dass die Bewertungen der Kunden nicht als skalare Variablen erfasst werden sollten. Die Gegenüberstellung der Ergebnisse der Hauptkomponentenanalyse mit den Ergebnissen der multiplen Regressionsanalyse zeigt, dass die Anwendung von Regressionsanalysen bei Versuchen mit großen Spannweiten und Interkorrelationen der Variablen nur eingeschränkte Aussagekraft haben.

Introduction

Plant quality in horticulture in most cases is seen from the producers or from the traders point of view. There is little knowledge about the way consumers make their decisions when they buy plants and different individuals have different preferences, when buying ornamentals (BENNINGA 1997a, BENNINGA 1997b). Additionally marketing theory points out, that situative factors and individual attributes of the consumers get more important for such decisions.

This research is an attempt to get more information about the relationship between measurable plant signs and consumer decisions. The aim of the research was to see wether multivariate statistical analysis methods are able to help discovering the importance of special plant signs or sets of plant signs behind the consumers choices.

Objective was one of most popular potplants in Germany, poinsettia.

Materials and Methods

In december 1997 in the main selling period for poinsettia a survey was carried out in the region of Wiesbaden, Germany. In four different horticultural firms one of four different sets, each consisting of 8 plants was presented to 247 customers in total. Four different sets of plants have been used, because the quality of the plants would have suffered due to the otherwise necessary transport of the plants. From a statistical point of view these sets can be seen as repetitions. The customers were asked to sort the plants depending on the order in which they would buy the presented plants. Each of the four sets of plants consisted of eight plants which had been choosen at random in two different horticultural production firms. Table 1 shows the plant signs which had been measured for each plant. The plants were an reflection of the ‚normal quality'. They were chosen on a way that plantsigns were as independent as possible. The four groups of eight plants

[1] Die detaillierten Daten individueller Idealwerte, individueller Ist-Werte, individueller (Un-)Zufriedenheitswerte (als Differenzen zwischen Ist- und Idealwerten) sowie Häufigkeitsverteilung für alle drei Wertekategorien liegen den Autoren vor.

Table 1. Plant signs involved in the survey
In die Untersuchung einbezogene Pflanzenmerkmale

Plant sign	Range	Data type
Number of berries	4–12	interval
Percent colour seen from top	20–70	ratio
Injuries of foliage	0.0–1.0	ordinal
Coverage with foliage	1–4	ordinal
Dark green or light green foliage	1 or 2	ordinal
Yellow foliage	0.0–2.0	ordinal
Number of flowers	2–10	ratio
Radius of flowers	13.5–29.5	ratio
Radius heart of flowers	1.0–3.0	ratio
Injuries of flowers	0.0–2.0	interval
Height of plant [cm]	33.0–48.0	ratio
Difference in height of flowers [cm]	1.0–22.0	ratio
Length of internodias [cm per leaf]	1.9–2.9	ratio
Relationship length to width	1.0–1.52	ratio
Standard deviation of flower radius	0.7–5.8	ratio
Relationship size of plant to heigth	18.43–37.38	ratio
Diameter seen from top [cm²]	648–1586	ratio
Degree of ripeness	0.0–2.0	ordinal

looked rather similar. A correlation analysis ensured that there were no statistical interdependencies between this plant signs.

Additionally the customers have been asked about the prices and the durability which they would associate with the best and the worst plant and wether they bought a poinsettia within the last year.

Descriptive statistical analysis have been applied to get an impression about the characteristics of the plants with the best and with the worst rating-scores. Multivariate analysis have been applied to show the relationship between plant signs and the ranking of the plants. The data were analysed with the SPSS-statistical package (multiple regression) and the CANOCO-statistical package (PCA).

In this experiment consumers give a preference-value to plants which themselves show several characteristics of different plant signs. There is no direct way to show the importance of plant signs for the ranking done by the consumers. The reason that Principle Component Analysis (PCA) in combination with regression analysis is used, is that the differences between consumers become visible in one figure as well as the importance of the plant characteristics. The basic matrix to make such biplots which visualize the different preferences of the customers is the one which contains the preference scores per plant per consumer. The similarity matrix of this basic matrix is decomposed by the matrix with its *eigenvalues* on the diagonal and result in the so called aspectmatrix and the factorscore-matrix. This is the normal method for PCA (figure 1). The biplot is formed by two of the principal components, the two with the highest eigenvalues and therefore the highest level of variance explanation. Each of the consumerscores is marked within the two axes. The vectors which correspond with the plant characteristics within the same biplot are constructed by mean of multiple regression, where the aspectmatrix is a function of plant characteristics values.

In formula: $Pc_i = f(\text{plant characteristics}) + e_i$

In this way the biplot gives an overview how the reaction of the consumers are related to each other, how the consumers preferences are related to the plant characteristics and wether any clustering in consumers preferences can be distinguished. A deeper explanation of the underlying mathematical model is given by TER BRAAK (1994). In the biplots presented in this paper the number of plant characteristics has been restricted to the ones with the highest loadings to get a better overview.

Results

Table 2. Description of the attributes of the "best" and of the "worst" plant in each shop
Beschreibung der Merkmale der „besten" und „schlechtesten" Pflanzen in jedem Befragungsort

Ranking of plant	Best plant				Worst plant			
Shop	1	2	3	4	1	2	3	4
Ranked as best/worst by how many of the customers	80%	57,6%	53,5%	69,4%	56,7%	39,4%	52,3%	64,3%
Number of berries	9	9	8	8	5	5	8	10
Percent colour seen from top	70	45	65	65	20	35	45	40
Injuries of foliage	0	0	0	0	0	0	0	1
Coverage with foliage	3	3	3	4	3	2	2	2
Dark green or light green foliage	1	1	1	1	2	2	2	2
Yellow foliage	0	0	0	0	2	2	1	2
Number of flowers	7	5	6	7	4	6	5	4
Radius of flowers	19,5	20,6	20,5	19	18,2	17,3	23,4	26
Radius heart of flowers	2	2,5	2	2	2	2	2,5	2,5
Injuries of flowers	0	1	1	0	1	2	1	2
Height of plant [cm]	44	48	36	38	37	33	44	44
Difference in height of flowers [cm]	22	11	12	11	12	13	13	14
Length of internodias [cm per leaf]	2,9	2,2	2	2,3	2,1	2,4	2,6	2,6
Relationship length to width	1,18	1,19	1,23	1,09	1	1,29	1,08	1,52
Standard deviation of flower radius	1,1	1,7	3,2	3,4	4,3	2,3	2,1	1,6
Relationship size of plant to heigth	27,1	28,5	31,7	31,6	21,6	23,9	29,5	30,5
Diameter seen from top [cm²]	1193	1368	1140	1199	800	788	1299	1344
Degree of ripeness	1,3	2,2	1	1	0	1	2	1

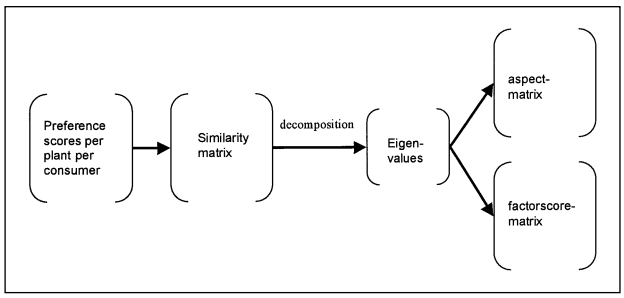


Fig. 1. Scheme of the decomposition of a principal component analysis
Schematische Darstellung der Aufspaltung bei der Hauptkomponentenanalyse

In each shop there were plants which have been choosen as "best" and as "worst" plants from a greater part of the customers. Only the items "Dark green or light green foliage", "Yellow foliage" and "Number of flowers" show influence. All plants with the highest ratings have dark green coloured foliage, all plants with the lowest ratings have light green foliage. None of the "best" plants has yellow foliage, all of the "worst" plants have yellow foliage. And the number of flowers seems to be higher for the plants with higher rankings. Other signs seem not to have any influence at all.

To test which of the plant signs are responsible for the ranking done by the customers a multiple linear regression analysis was performed. The ranking was the dependent variable and the plant signs the independent variables. The model of the regression analysis assumes, that ranking is an additive process.

To be able to compare the influence of the different plant signs by their regression coefficients, the variables have been normalised before starting the regression analysis. Different methods of regression analysis have been applied to the data of each shop. The differences were related to the method variables were included or excluded within the regression analysis. All of the analysis lead to regression equations with different included variables and a maximum of 58 percent explained variance. Not one of the variables was included into the equations for all shops. There are also some variables, for example the difference in height of the flowers which are included into the regression equations with positive coefficients for one shop and with negative coefficients for other shops. Table 3 shows the results of the regression analysis method "Enter" (all variables are entered in one step) for each of the four shops.

The customers have been asked what prices and what durability they would expect for the plant they gave the highest and the lowest rankings. Descriptive statistics for those answers can be seen in table 4. For each of the variables there are great differences and high standard deviations. For example there have been customers who expected the same durability for the best and for the worst plants and there also have been customers who expected a year difference! To show the great differences table 4 shows also the differences between the estimated durability and the differences between the estimated prices for the plants with the highest and with the lowest ranking; there is no relation between endurence and expected price. 75 percent of the interviewed customers bought a poinsettia within the last year.

Figure 2 shows two of the biplots which are the result of the combinated principal component and regression analysis. The upper biplot shows that for the major part of the customers plant characteristics 1 (Dark green or light green foliage) and 7 (Yellow foliage), 2 (Diameter seen from top) and 10 (Radiation of flowers) are the most important ones because their weightet scores are

Table 3. Coefficients of standardised plant-variables, entered in a multiple regression analysis in different shops, method Enter
Koeffizienten der standardisierten Variablen als Ergebnis einer multiplen Regressionsanalyse für jede Einkaufsstätte, Methode Enter.

Shop	1	2	3	4
R Square	0,59	0,49	0,53	0,48
R Square adjusted	0,58	0,47	0,52	0,47
Constant	4,87	5,47	4,46	4,36
Variable	coeff.	coeff.	coeff.	coeff.
Number of berries			–0,35	
Percent colour seen from top	–0,30			–1,11
Injuries of foliage			–0,51	–0,18
Coverage with foliage			–1,26	
Dark green or light green foliage				
Yellow foliage				
Number of flowers				
Radius of flowers			1,81	0,35
Radius heart of flowers	0,51	0,79	–0,04	
Injuries of flowers	0,96			
Height of plant [cm]	0,08	–1,83		
Difference in height of flowers [cm]	–0,43	–0,20		0,42
Length of internodias [cm per leaf]				
Relationship length to width		–1,19		0,77
Standard deviation of flower radius	0,36	1,05		
Relationship size of plant to heigth		0,59	–0,83	–0,52
Diameter seen from top [cm²]				
Degree of ripeness	–0,46	0,13	0,79	0,11

Table 4. Prices and durabilities for worst and best plants estimated by customers
Von den Kunden geschätzte Preise und Haltbarkeiten für beste und schlechteste Pflanzen

	Min	Max	Mean	Std. Dev.
Difference of estimated durability of worst and best plant	0	365	15,0	41,8
Difference of estimated prices for worst and best plant	0,0	16,0	4,11	3,54
Estimated durability of the best plant in days	8	1080	100	126
Estimated durability of the worst plant in days	7	1080	85	126
Estimated price for the best plant	4,00	35,00	13,18	5,44
Estimated price for the worst plant	2,50	25,00	9,08	4,43

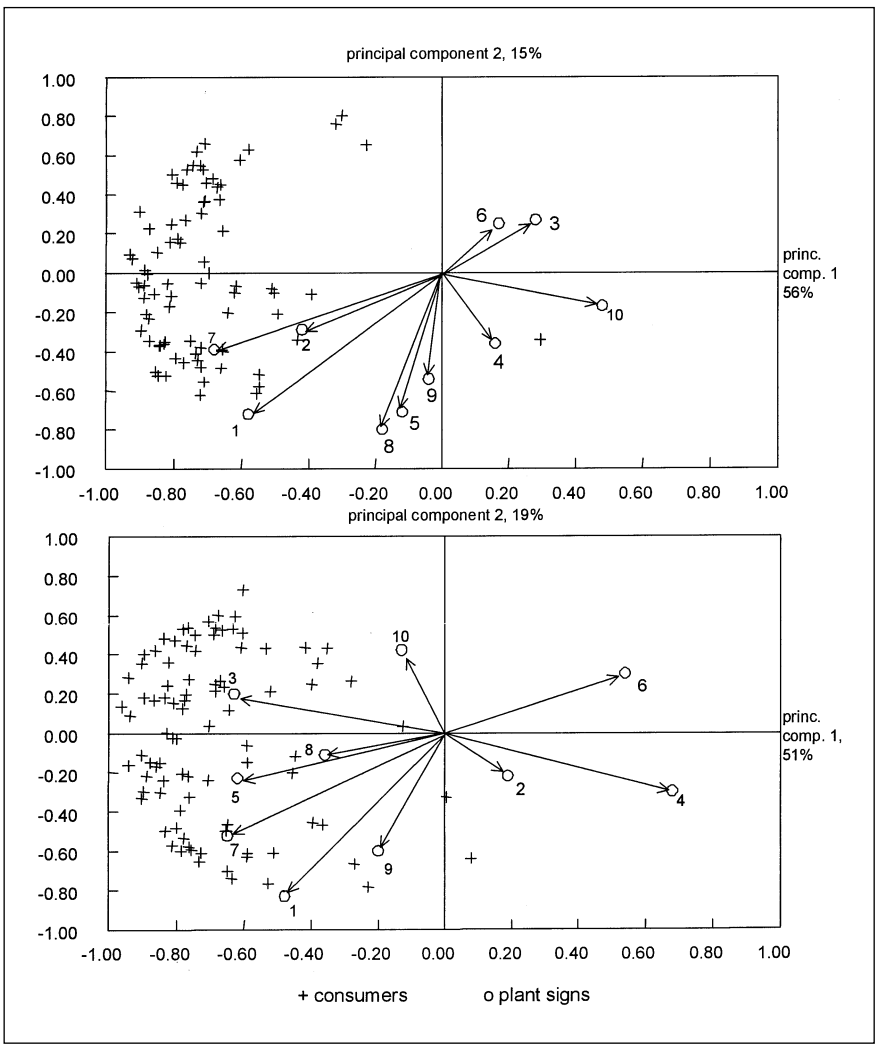


Fig. 2. Biplots of preference scores per plant and per customer (crosses) and plant signs (vectors) for two different shops
Biplots der Pflanzenbewertungen durch die Kunden (Kreuze) und der Pflanzenmerkmale (Vektoren) für zwei Untersuchungsstandorte

1. Dark green or light green foliage
2. Diameter seen from top
3. Relationship length to width
4. Number of flowers
5. Radius of flowers
6. Percent colour seen from top
7. Yellow foliage
8. Height of plant
9. Number of berries
10. Radiation of flowers

the highest on the both axes. Plant signs 7 and 2 correlate which means that the effect to consumer decisions in this shop caused by this signs had been similar. Plant sign 10 is rather important and it is independent of the other plant signs. In this experiment the consumers react rather simular, with some exceptions.

The lower biplot in figure 2 is the result of a parallel experiment in an other shop with different plants. In this experiment more plant characteristics are important and there seem to be different groups of customers with distinct preferences. The vertical axis is more important in this experiment than the upper diagram because more variance is explained. The consumers preferences are more diverged around the left side of the biplot. Three groups of consumers can be distinguised. The group for which sign 3 (Relationship length to width) and complementarely sign 4 (Number of flowers) are most important, the group which considers especially sign 7 (Yellow foliage), sign 5 (Radius of flowers) and complementary sign 6 (Percent colour seen from top) and a third group, which prefers dark leaved Poinsettia's (sign 1) and a larger number of berries (sign 9).

Discussion

Although there are plants which are preferred or which are rejected by a great part of customers in each shop it seems to be very difficult to lead back customers decisions to single plant signs or to simple combinations of plant signs.

The approach that consumer decisions about ranking poinsettias are the result of adding single decisions can not be proved. Not even the same variables are identified as relevant within regression analysis and also only approximatly 50 to 60 percent of the variance can be explained by the variables covered within this regression analysis. It seems remarkable, that the same plant signs which are important for all best plants (table 2) are missing in regression analysis (table 3).

Although the customers involved in the study were customers, which entered a horticultural firm or garden center to buy a plant and although 75 percent of them bought a poinsettia within the last year there seem to be very little knowledge about the durability of the plants and about the prices.

The biplots have similarities and differences. Leaf-colour and yellow foliage are important plant characteristics. The importance of the other characteristics dif-

fers more or less. This is due to the capriciousness of consumers and this shows how difficult it is for growers to satisfy a large number of consumers or to serve certain market segments. On the other hand, knowing this, growers only have to take care about certain plant characteristics and take care that the rest of the plant signs is acceptable.

There may be two major reasons for the low relationship between plant signs and consumer decisions shown in this analysis. One may be that there is a great influence of attributes which have not been part of the survey. Of influence could be attributes of the consumers personality and also situative factors like atmosphere in the shop, presentation of the plants and similar factors. The second reason may be that the ranking of the single plants has been recorded as scalar value. From a statistical point of view there may be a clearer relationship between plant signs and consumer decisions if the ranking of the plants would reflect real distances between the plants.

In general this research shows that multiple regression analysis is not very useful for this kind of analysis because research about consumer reactions lead to variables with large ranges and high levels of intercorrelations.

Literature

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