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GENOTYPE X SEASON INTERACTION AND STABILITY PARAMETERS IN BLACK PEPPER (*PIPER NIGRUM* L.)

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The genotype x environment interaction can be considered as the variation that arises from the lack of correspondence between the genetic and non-genetic factors on the development of an individual; and is widely observed to play an important role in the phenotypic expression of crop plants. Complications arising from differential response of genotypes to environments have been considered in detail by many workers including Comstock and Moll (1963), Allard and Bradshaw (1964), Breese (1969) and Hill (1975). In a view to overcome this difficulty, the breeders often resort to the evolution of varieties specifically adapted to different environments. However, it leaves the possibility of changing environments in the same locations over seasons unaccounted for.

The present study is to investigate into the role of genotype x environment interaction; or more specifically the genotype x season interaction, in black pepper. Also, the study envisages the description of five varieties of black pepper with respect to their stability parameters.

Materials and Methods

The material for this study was comprised of five varieties of black pepper viz., Panniyur, Arakkulam Munda, Kalluvally, Balankotta and Kuthiravaly, replicated five times, at the Pepper Research Station Panniyur, Taliparamba. The weight of green spikes was recorded on per plant basis for five years from 1979-80 to 1983-84.

The data obtained from the field for individval seasons were analysed separately as per the routine method of analysis of variance The technique suggested by Finlay and Wilkinson (1963) modified by Eberhart and Russell (1966) was utilized to describe the stability parameters of the varieties. The parameters of stability can be defined in a mathematical model as follows:

$$Y_{ij} = m_i + \beta_i I_j + \delta_{ij}$$

Where Y_{ij} is the mean of i^{th} variety in the j^{th} environment, m the mean of the varieties over all the environments, β_i the regression coefficient of the i^{th} variety on the environmental indices, I_j the environmental index of j^{th} environment and δ_{ij} the deviation from regression. The environmental indices were computed as $I_j = \sum_i Y_{ij} / t - \sum_i \sum_j Y_{ij} / ts$ where t and s are the number of varieties and environments respectively.

Results and Discussion

The spike yields for the varieties during the five seasons under the experiment were as given in Table 1 , The variety Kuthiravaly has outyielded other varieties during three seasons. Results of analyses of variance done for individual seasons are provided in Table 2. The varietal variation was found to be highly significant for first three seasons (P <0.01) whereas no such variation was observed during the following two seasons. Genotype x environment interaction in black pepper was analysed, partitioned and tested; results of which are given in Table 3. Both varietal and environmental components were tested against mean square of pooled deviation and was found to *be* highly significant (P<0.01). The genotype x environment Interaction was found to play substantial role in the phenotypic expression of black pepper for yield (significant at P<0.01 }.

Table 1

The green spike yield of the varieties during five seasons (g/plant)

	1979-80	1980-81	1981-82	1982-83	1983-84
Panniyur 1	2647.6	92.4	3300.6	1592.4	474.0
Arakkulam Munda	1548 8	31,2	2135.8	1797.2	825.5
Kalluvally	74.8	144.2	641.2	1155.4	267.4
Balankotta	215.2	200.9	1996.6	1772,6	336.2
Kuthiravaly	1366,6	922,6	3477.8	2136.0	590,5
C. D. at *5%*	9334	239.4	1209,1	*	

The varietal mean square was not significant

Table 2

Analyses of variance of spike weight (g/plant) during various seasons

Source	df	Mean square deviation 1979-80	1980-81	1981-82	1982-83	1983-84
Replication	4	1246470	57024.5	3496508*	407135	502873*
Variety	4	5595683**	517377.3**	6573128**	640688	244651
Error	16	484670	31892.7	813207	434078	157787

* Significant at P <0.05

** Significant at P <0.01

Genotype x environment interaction constitutes an important limiting factor in the estimation of variance components and the efficiency of selection programmes. However, little is known about the environmental factors which contribute to such interactions. Even if such information were available the possibility of materially reducing such interactions under field conditions appears somewhat questionable (Sprague, 1966). Comstock and Moll (1963) have stated that larger the interactions, lesser are the chances of progress under selection in a breeding programme.

The genotype x environment interaction was split into linear and non-linear components and their significance was tested (Table 3). Though, the linear component, when tested against pooled deviation (non-linear component of interaction), was not significant at ordinarily chosen levels of probability, the regression coefficients of various varieties may be thought of as varying with one another at P <0.20. On the other hand, pooled deviation was observed to be significant at P <0.01. It is thus evident that the genotype x environment interaction was largely contributed by the non-linear component thereby suggesting that certain amount of unpredictability would govern the performance of varieties in general.

Table 3

Analysis of variance for phenotypic stability in spike weight (g./plant)

Source	df	MS	F
Total	24	—	—
Varieties (V)	4	6564916	5.56**
Environment (Env)	4	17827048	15.11**
V x Env	16	1751653	4.56**
Env + (V x Env)	20	—	—
Env (linear)	1	—	—
V x Env (linear)	4	2582516	2.19*
Pooled deviation	15	1179759	3.07**
Pooled error	100	384327	—

** Significant at P < 0.01

• Significant at P < 0.20

Significant contribution to the interaction by both linear and non-linear components was noted by several workers in various crops regarding yield viz., Malhotra *et al.* (1971), Verma *et al.* (1972), Paroda *et al,* (1973), Chowdhury and Haque (1977), Chaudhary *et al.* (1978) and Ibrahim (1980). On the contrary, Yassin (1973) in field bean and Gautam and Jain (1977) in wheat have noticed the non-linear component of interaction alone to be significant for yield.

In the light of significant interaction being noticed in the yield character of black pepper, it becomes necessary to place emphasis on consistency as well as performance in the selection of varieties. The varieties, that are selected on the basis of higher mean yield only, in the absence of information on phenotypic stability, may be relative failures under adverse conditions. Further, generally high yielding types were observed to be increasingly susceptible to the environmental variation in various crops, as evidenced by significant positive association between yield and regression coefficients (Perkins and Jinks, 1968; Hanson, 1970; Tail 1971; Verma *et al.*, 1972; Brennan and Byth 1979; Mehra and Ramanujam, 1979 and Ibrahim, 1980).

It is evident from the above discussion that some measure of stability must be employed to avoid the complications arising from the interaction of genotypes with the seasons. Various methods for the measurement of stability were devised by several workers. However, the present study is largely dependent upon the method suggested by Finlay and Wilkinson (1963) and modified by Eberhart and Russel! (1966) for the elucidation of genotype x environment interaction and stability parameters in black peppar.

Various parameters of stability for the varieties are provided in Table 4. Responsiveness of varieties to seasonal variation (regression coefficients) was observed to vary from 0.346 for Kalluvally to 1.425 for Panniyur 1. The variety Kalluvally comes close to satisfying the stability concept of Finlay and Wilkinson (1963) according to whom the regression coefficient should tend to zero. Kalluvally has also shown the lowest yield and a non-significant deviation from regression thereby identifying itself to be a uniformly poor performer over the seasons, EberharT and Russell (1966) differ from Finfay and Wilkinson (1963) in as much as that regression coefficient should tend to unity for a variety to be stable as would be preferred by breeders. The varieties Arakkulam Munda and Balankotta more readily agree to regression slope being equal to unity. However, in variety Balankotta, the deviation from regression being significant, it cannot be termed as a stable variety. Moreover, the yielding ability was also seen to be poor. Arakkulam Munda, in addition to showing regression and deviation from regression in accordance with stability, has given an average yield, but less than that of Panniyur 1 and Kuthiravaly.

The varieties Panniyur 1 and Kuthiravaly have shown good yield and rather high regression slopes. They can be considered to respond favourably to favourable environments. But this relatively higher regression slopes will also suggest poor performance during unfavourable seasons. Of these two varieties, Kuthiravaly was endowed with comparatively more stability over seasons than Panniyur 1. The poorest performance by Kuthiravaly was during the year 1980-81 and it was noted that the yield for this variety stood favourably in comparison to other varieties, during that year.

Table 4

Stability parameters of the various varieties for spike yield

Variety	Spike yield (g/plant)	Regression coefficient	Deviation from regression
Panniyur 1	1621.40	1 .425	2508562**
Arakkulam Munda	1267.69	0.943	116953
Kalluvally	456,59	0.346	383033
Balankotta	904.31	0.954	689771 *
Kuthiravaly	1678.70	1.332	278840

* Significant at $P < 0.05$

** Significant at $P < 0.01$

The variety Panniyur 1, besides having good yield and highest regression slopes, had deviation from regression significant at $P < 0.01$. Regression analysis of variance had shown that the variation due to regression was highly significant. It reveals that even after considerable reduction in the residual variation by fitting an appropriate linear regression slope, it has still remained large enough to render the prediction of varietal performance based on regression ineffective. Though, in general, Panniyur 1 was a good performer, its performance during all seasons could not be relied upon as suggested by its unpredictable nature. This nature of the variety may prove detrimental to pepper growers who have no staying power.

The variety Panniyur 1, despite its inconsistency, should be regarded as superior to varieties Arakulam Munda, Kalluvatly and Baiankotta, since these varieties failed in the most important parameter of stability namely yield. Frey (1964) reported that a good adaptable variety gives superior production over a wide range of environments. Bains and Gupta (1972) suggested that, the potential of genotype to express greater mean over environments should be the most important criterion, if at all an importance must be attached To a particular parameter, since the other parameters may not be of any practical utility, if the genotype is potentially weak. The Panniyur 1 falls very much in lines with these thinkings whereas the above mentioned three varieties fail.

Breese (1969), Samuel *et al.* (1970), Paroda and Hayes (1971) and Paroda *et al.* (1973) emphasized that the linear regression should simply be regarded as a measure of response of a particular variety, whereas the deviation from regression line should be considered as a measure of stability, varieties with lowest deviation being the most stable and vice-versa. Varieties Arakkulam Munda, Kalluvaily and Kuthiravaly might be considered as fulfilling this criterion.

Considering all the three parameters of stability simultaneously, it may be said of Kuthiravaly as the variety to give consistently better yields than other varieties over the seasons, barring rare occasions wherein seasons would be markedly poor. Of the other varieties, Panniyur 1 may be considered superior.

Low values for deviations from regression when obtained indicate that the linear regression model will suffice to explain the trend of response of the varieties and predict the phenotypic expression of these varieties in different environments with accuracy within the limits of sampling error. However, varieties Panniyur 1 and Balankotta expressed significant deviations from regression thereby showing that the linear models of regression did not give good fit to the observed data in their cases. This suggests for the need of a higher order regression to measure the response more accurately (Jinks and Pooni, 1979). It has been pointed out that the best polynomial regression would be a (n–1) regression model when there are sets of observations. Since, the present study has only five environments, a quadratic regression mode! can be utilized to obtain an accurate trend of response of genotypes to environments. It may be noted that incorporation of (n–1) polynomials in a curvilinear regression, will make the degrees of freedom for residual variation, in a regression analysis, equal to zero. Verma *et al*. (1978) proposed two intersecting straight lines model to fit the observations. At this juncture, it may be proposed a curvilinear regression in the form of an exponential growth curve as most ideally describing a good adaptable variety.

On the basis of the varieties Kuthiravaly and Panniyur 1 being identified as the superior varieties, quadratic regression models were constructed based on their performances. Table 5 shows that the variety Kuthiravaly exhibits considerable curvilinearity for their values on environmental indices. The quadratic model fitted for their variety Kuthiravaly was $Y = 716.81 - 0\ 20389x + 0.00061x^2$ and it was differentiated into -0.20389 x $0.0012x$ following the routine steps of differentiation in calculus. It was found in this study that the limiting value of $\Delta y/\Delta x$ when $\Delta x \rightarrow 0$, ie., $dy/dx = cY$ where c is a constant and Y the value of yield on particular levels of x. Hence, the performance of the variety Kuthiravaly on the environmental indices has followed exponential growth curve (Snedecor and Cochran, 1968). Kuthiravaly thus can be considered to respond considerably to better environments and at the same time maintain a respectable minimum, when the environments tend to be poor. As for Panniyur 1 significant departure from linear regression could not be established.

The present study involved the performance of five varieties over five seasons. Whether the stability of varieties as described for the season would he relevant when the environments were represented by the locations, had also to be tried. Studies on the stability parameters may also be included in the routine multilocation trials to gather more information on the nature of varieties.

Source	df	SS	MS
Deviation from linear regression	3	397900	—
Deviation from curved regression	2	38607	19303.5
Reduction in sum of squares	1	359293	359293*

F = 359293 19303.5 = 18.61*

* Significant at $P < 0.05$

Summary

Genotype x season interaction and stability parameters for five varieties of pepper for yield was studied at the Pepper Research Station, Panniyur, by utilizing the data recorded over five seasons from 1979-80 to 1983-84. The genotype x season interaction was observed to be significant and a larger portion of it was through the non-linear component. The stability model proposed by Eberhart and Russell (1966) was resorted to in describing the stability parameters of varieties. In this study, the variety Kuthiravaly, was found to be the most stable variety. Panniyur 1 is a high yielding variety especially suited to favourable environments, but can also be considered as more stable variety than Arakkulam Munda, Kalluvally and Balankotta.

സംഗ്രഹം

പന്നിയൂർ കുരുമുളക് ഗവേഷണകേന്ദ്രത്തിൽ 1979–80 മുതൽ 1983-81 വരെയുള്ള കാലയളവിൽ, അഞ്ചു കുരുമുളക് ഇനങ്ങളിൽ നടന്ന പരീക്ഷണത്തിൽനിന്ന്, അവയുടെ 'ജീനരൂപം × കാലം പ്രതിപ്രവർത്തനം' പഠിക്കുകയുണ്ടായി. കൂടാതെ അഞ്ചു ജനുസ്സുകളുടെയും 'സ്ഥിരതാപരമാപകങ്ങളും' പരികലനം ചെയ്തു. പ്രതിപ്രവർത്തനം മൂലമുള്ള വ്യതിയാനം അധികഭാഗവും ഏകഘാതമല്ലാത്ത രീതിയിലാണ് കാണപ്പെട്ടത്. വിവിധ കാലങ്ങളിലും ഉൽപാദന സ്ഥിരത നിലനിർത്തുന്ന ഒരിനമാണ് 'കുതിരവാലി' എന്നു കാണപ്പെട്ടു. പന്നിയൂർ 1 എന്ന ഇനം മററുള്ള ഇനങ്ങളേക്കാളും മെച്ചമാണെന്ന് കണ്ടു.

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