"ADAPTATION ANALYSIS FOR YIELD AND ITS ATTRIBUTES IN BLACK GRAM (*Vigna mungo* L.)"

THESIS

SUBMITTED TO THE

Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.)
in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE
IN
AGRICULTURE

(PLANT BREEDING AND GENETICS)

By

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2003

CERTIFICATE – I

This is to certify that the thesis entitled **"Adaptation analysis for yield and its attributes in black gram (*Vigna mungo* L.)"** submitted in partial fulfilment of the requirement for the degree of "Master of Science in Agriculture **(Plant Breeding and Genetics)** of the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur is a record of bonafide research work carried out by **Shri Sachin Kanslya,** I.D. No. A/IN-349/96 under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma or has been published. All the assistance and help received during the course of the investigations have been duly acknowledged by him.

Place: Indore **[Dr. Mridula Billore]**

Date 01st August, 2003 **Chairman of the Advisory Committee**

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CERTIFICATE – II

This is to certify that the thesis entitled **"Adaptation analysis for yield and its attributes in black gram (*Vigna mungo* L.)"** submitted by **Shri Sachin Kanslya,** I.D. No. A/IN-349/96 to the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, in partial fulfilment of the requirement for the degree of **"MASTER OF SCIENCE IN AGRICULTURE"** in the Department of **Plant Breeding and Genetics**, has after evaluation, been approved by the external examiner and by the Student's Advisory Committee after an oral examination of the same..

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Date 13 th May, 2004

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ACKNOWLEDGEMENT

The expressivity of feelings by words subdues its significance, yet gratitude to the benefactor is a virtue and to express it in some form, however, imperfect is the duty towards who helped.

In this scalar chain, the most vivid name that superbly comes out is of my revered teacher and chairman of advisory committee Dr. Mridula Billore, Associate Professor, Department of Plant Breeding & Genetics, whose judicious guidance helped to define the objectives, methodology of the program and constant encouragement helped me in bring out this work which made the study thoroughly stimulating and rewarding experience.

I wish to express my most sincere and deepest sense of gratitude and indebtedness to the members of the Advisory Committee Dr. P.K. Mishra, Principal Scientist, Department of Plant Breeding and Genetics, Dr. V.K. Mishra, Associate Professor (Botany) and Dr. S.K. Agrawal, Senior Scientist (Statistics), for their invaluable guidance and suggestions, constructive criticism, which have resulted this investigation in the present form.

I feel immense pleasure to express my heartiest thanks to Dr. J.S. Raghu, Dean, College of Agriculture, Indore for providing necessary facilities and help during the course of investigation.

At the same time, I have immense pleasure in expressing my thanks to all the officers of Krishi Vigyan Kendra, Dhar and Krishi Vigyan Kendra, Jhabua who provided all the facilities and co-operated fully in carrying out the research problem at these stations. It is my special pleasure to express deep appreciation to my friends Mr. Rahul Jain, Mr. Jitendra Patel, Mr. Sandeep Jadiya, Mr. A.C. Jha, Mr. Ashish Bharillya and to all my seniors and juniors who helped me during my thesis work in one way or the other.

I find no rhetorical gems from the ocean of words to express my profound feelings to my most venerable parents Shri S.K. Jain, Smt. Kamla Jain and all the other members of my family whose affection, sacrifice, enthusiastic inspiration, devotion and care made it possible for me to achieve this goal and whose blessings have been a perennial source of inspiration throughout my study.

Place: Indore

Date: 01st August, 2003

(SACHIN KANSLYA)

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INTRODUCTION

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INTRODUCTION

Uridbean [*Vigna mungo* (L.) Hepper] belongs to family leguminosae and sub-family papilonaceae, referred to as blackgram, is one of the main pulse crops grown in India. It is native to Asia (Indian sub continent). It is a tropical plant, resistant to high temperature and sensitive to cloudy weather and cannot tolerate frost.

In India, urid is grown on a large scale in many states including Maharashtra, Madhya Pradesh, Uttar Pradesh, TamilNadu and Andhra Pradesh as a kharif crop, it can be grown in rabi as 'utera' and summer also, where the irrigation facilities are available. The productivity of this crop in M.P. is very low in comparison to the above mentioned states in all three seasons. The main reason for low productivity of urid in this area is growing of traditional late maturity varieties which are shy bearers, poor agronomical management and least emphasis on control of pest and diseases.

Blackgram is one of important pulse crops providing grain for human consumption and fodder for cattle and besides, it can be used as a cover crop due to its heavy foliage in the area where soil erosion is a problem. Blackgram can undoubtedly occupy an important position among the pulse crops because of its duration that could be mixed cropped along with other crops.

The phenotypic expression of an individual depends on its genotype and the environment surrounding it (Johansen, 1903). The effects of genotype and environment on phenotype may not be always independent the phenotypic response to change in environment is not same for all the genotypes. The consequences of variation in phenotype depend upon environment. Very often breeders encounter situations where the relative rankings of varieties change from location to location and/or from year to year. The interplay in the effect of genetic and non-genetic on development is termed as "genotype environment interaction" (Comstock and Moll, 1963).

Varietal adaptability to environmental fluctuations is important for the stabilization of crop production both over regions and years. Adaptability is the ability of a genotype to exhibit relatively stable performance in different environments. In any crop breeding programme, it is important to identify a genotype with high yield potential with stable performance over a wide range of environments.

Phenotypically stable varieties are usually sought for commercial production of crop plants, and it is necessary to screen and identify phenotypically stable genotypes, which could perform more or less uniformly under different environmental conditions. The high yielding genotypes may not remain high yielding in all environments so such breeding efforts are required, that provide us the information regarding the extent of genotype x environment interaction for the yield and more particularly for the interaction between component characters of yield and environments. Therefore, the stability of yield in different environments is an important criterion in discriminating varieties. The method suggested by Eberhart and Russell (1966) based on some modification of Finlay and Wilkinson (1963) for studying the adaptability of crop varieties makes it possible to evaluate the relative stability with respect to their performance.

The main objective of any efficient plant breeding programme is to increase the yield. The existing varieties of Blackgram may not give high yields in all environments. It may be due to the differential performance of genotypes under varying environments, and their interaction with the environments, therefore, knowledge of stability of different varieties over a wide range of environments is of great importance.

Also, it is well known that for a less favoured farmer, stability of crop production is more important than high yields based on high investments. Hence, a discussion on genotype x environment interaction throws light on the magnitude of environmental effects on varietal adaptation and performance and thus, helps to further the efficiency of breeding for well adapted varieties.

In order to measure phenotypic stability in the performance of genotypes, various stability models are being used. Statistical approach of Finlay and Wilkinson (1963) to measure phenotypic stability was based on the regression analysis. A linear stability model proposed by Eberhart and Russell (1966) based on some modification of Finlay and Wilkinson (1963) has proved considerably useful to measure phenotypic stability in the performance of genotypes. Perkins and Jinks (1968) developed an analysis known as joint regression analysis, to measure genotype x environment interaction and to identify stable genotypes.

Keeping the above information in view, this investigation has been planned to study the effect of locations in blackgram with the following objectives:

1. To determine the genotype x environment interaction over locations.
2. To know the adaptability of genotypes for yield and its attributes over three locations viz., Indore, Dhar and Jhabua.
3. To find out the stability of traits over varying environmental conditions.

CHAPTER - II

REVIEW OF LITERATURE

CHAPTER – II

REVIEW OF LITERATURE

The research work done in India and elsewhere in recent years on stability analysis in black gram and related crops viz., green gram and cowpea have been reviewed in this chapter.

The following stability analysis studies have been reported in blackgram.

Sreekantaradhya *et al.* (1978) carried out analysis of variance of yield data of a trial involving ten Indian varieties of *Vigna mungo* repeated consequently for four years, which revealed that variance due to varieties was not significant but that the variety x year interaction was significant. On the basis of average yield, US-131 was the best variety, followed by Kh-3 and T-9. The genotype US-131 produced the highest number of pods per plant, while Kh-3 produced the highest number of seeds per pod.

Wanjari *et al.* (1981) laid out trials with nine *Vigna mungo* cultivars grown at four locations during 1973-76 and observed significant genotype x environment interactions. Cultivars T-9 and UPU-1 gave the average seed yields of 1.15 and 1.04 t/ha, respectively, compared with 0.43 to 0.86 t in other cultivars.

Yadav and Kumar (1983) derived data from stability analysis of yield and six yield-related characters in 31 cultivars of *Vigna mungo* indicated that different stability parameters were independent of one another. Early flowering varieties with low yield were found to be the most stable. The population as a whole showed low stability for yield. Further, they studied stability for seed size in blackgram. The data of 100-seed weight of 31 *Vigna mungo* cultivars grown under 3 environments indicated that in about 18 genotypes which showed stability, the bold seeded cultivars H 76-16 and H 76-15 were appreciably stable. The smallest seeded cultivar, PU-26, seemed suitable for a wide range of environments.

Patil and Narkhede (1989) studied phenotypic stability of yield, seeds/pod and 100-seed weight in blackgram, and information on genotype x environment interaction is derived from data on these 3 traits in 14 genotypes grown during 1980-84. The interactions were significant and the genotypes differed considerably in stability for the traits. The varieties viz., RU 77-29-10 and RU 77-51-4 were found to be the most stable for yield and appeared as promise for use in breeding.

Mishra (1990) studied genotype x environment interaction and stability performance in blackgram and reported preponderance of non-linear component as compared to the linear component for seed yield.

Muduli and Hati (1994) laid out a trial on eight blackgram and 22 greengram genotypes, grown in the West-Central tableland region of Orissa during rainy seasons of 1987-91. Significant differences in seed yield were observed among genotypes and environments, indicating genetic variability in both pulses. Genotype x environment interaction and variances due to environment and GE interaction were significant. Of the blackgram genotypes, UH 80-7 was the most stable genotype for cultivation in this region.

Singh *et al.* (1994) laid out a trial with seven blackgram genotypes and information on stability was derived from data on grain yield grown at Berhampur during the winter seasons of 1985, 1986 and 1987 and the rainy seasons of 1986 and 1987 and at Bhubaneshwar during the rainy season of 1988. Significant genotype x environment interactions for seed yield were observed.

Singh *et al.* (1994) carried out a trial with twenty blackgram genotypes grown under four artificial environments, during 1986 and 1987 and observations recorded for eight physiological stability parameters. Analysis of variance for stability parameters revealed significant differences among the genotypes and environments for seed yield.

Stability in seed yield was associated with stability in certain physiological parameters.

Mandal and Pal (1995) conducted a field trial during the rainy season of 1992 at Jhargram, West Bengal with nine *Vigna mungo* cultivars and found that the genotype x environment interactions were significant. The variety Pant U-19 gave the highest yield per plant (2.22 g) followed by T-9 (2.21 g), B-76 (1.76 g) and PDM 87-14 (1.66 g). Yields from the other cultivars were significantly lower.

Chakraborty *et al.* (1997) evaluated eight genetically diverse black gram genotypes over four locations for stability of two traits (days to 50% flowering and days to maturity). Genotypes, environments and genotype x environment interaction effects were highly significant for both traits. The G x E (linear) effect was highly significant, indicating the possibility of predicting the phenological traits over environments. Significant pooled deviations in the case of days to maturity revealed that variation in maturity was caused by some unpredictable factors. For days to 50% flowering, T-9 was the most stable genotype whereas PU-30 was the most stable for days to maturity.

Chakroborty and Borua (1997) studied stability for seed yield in eight blackgram genotypes in four environments in Assam, India. Genotypes, environments and genotype x environment (G x E) interaction effects were highly significant. G x E (linear) effects were not significant, which indicated that yield performance could not be predicted over environments. Significant pooled deviations showed that variation in the seed yield was influenced by some unpredictable factors. Genotypes viz., T-9, VB-15 and KU 92-1 gave high yield and were found to be the most stable varieties. These varieties were also reported to be suitable for commercial cultivation in Assam.

Manivannan (1999) conducted a field experiment of 21 black gram genotypes grown in four environments during 1995-97 at Vamban, and stability for seed yield was evaluated in these 21 genotypes. Analysis of variance for stability of seed yield showed significant differences amongst the genotypes. Nine genotypes showed stability for seed yield. These results combined with genotype grouping indicated that the genotypes VBG-42, VBG-52 and VBG-57 were the most superior genotypes.

Manivannan *et al.* (2002) studied stability of five urdbean genotypes in six environments. The two components of G x E interaction i.e., G x E (linear) and pooled deviation were significant against pooled error indicating differences among the genotypes for linear and non-linear responses to environment. The study also revealed the preponderance of non-linear component as compared to the linear component for seed yield. The genotype AB-2045 showed stability with average responsiveness to environment for seed yield. Based on stability factor and genotype grouping technique, VBG-17 and CO-5 showed stability.

The following stability analysis studies have been reported in greengram (*Vigna radiate*) and cowpea (*Vigna unguiculata*).

Patil and Narkhede (1989) reported information on stability and genetic and environmental variance derived from data on seeds/pod and mean seed yield in 16 greengram genotypes grown during 1981-85. the genotype RM 75-25-6-10 was recorded to be the most stable one and would be accepted for commercial cultivation.

Thiyagarajan and Rajasekaran (1989) carried out stability analysis for seed yield and its components in cowpea. Different cowpea genotypes were grown in six different environments. Observations were recorded on days to 50% flowering and days to maturity on plot basis, and data assembled for the characters viz., plant height, primary branches, pods/plant and yield per plant, seeds per pod and 100-seed weight. Analysis of variance showed variation among genotypes as well as environments. Genotypes CO-4 and COVU-4 were stable for all characters and could be directly exploited for yield improvement.

Reddy *et al.* (1990) collected data on seed yield, pods/plant and plant height for 11 *Vigna radiata* genotypes grown during rainy seasons of 1986 and 1987 in two environments. Pods/plant had the greatest effect on yield stability. As per the stability analysis, varieties Pusa-115 and UPM 79-4-12 are recommended for favourable environments.

Patil and Sonawane (1992) derived information on genotype x environment interaction from data on green and dry forage yield in eight genotypes of forage cowpea grown during *kharif*, *rabi* and summer seasons of 1985-86. Significant differences wee observed due to environment and genotype x environment interactions. Stability was identified for dry forage yield in genotype No.10 in better environments and in both No.457 and No.10 for green forage yield under poor environments.

Naidu *et al.* (1993) evaluated 20 genotypes of greengram in 6 environments at Lam, Andhra Pradesh during 1987-89, and information on stability parameters is derived from data on seed yield. The highest yielding genotypes were LGG-410 and LGG-407 (1332 and 1298 kg/ha). Genotypes PDM 84-145, PDM-54, K-851 and ML-267, with relatively high mean seed yields (1057 to 1117 kg/ha) were considered stable.

Sharma *et al.* (1993) derived information on stability and genotype x environment interaction from data on six yield-related traits in ten promising *Vigna radiata* varieties grown at Dhiphu in Assam hills during the summer seasons of 1989, 1990 and 1991. Significant genotypes x environment interactions were found.

Patil and Narkhede (1995) carried out stability analysis fore 100-seed weight, pods/plant and seed yield in greengram. Information on genotype x environment interaction and stability is derived from data on three yield components in 16 green gram genotypes during kharif, 1981, 1982, 1983 and 1984 in Jalgaon. Pooled analysis of variance revealed high G x E interaction for 100-seed weight, pods/plant and seed yield.

Kalpande *et al.* (1996) evaluated seed yield and five yield components in 24 genotypes of green gram sown during kharif, late kharif and summer 1993. Mean differences among the genotypes were significant for most of the characters studied. Stability parameters revealed that TAP-7, JLM-4 and TAM-9201 had high yield potential with stable performance. Phule M 2-70 was recommended for poor environments and TARM-18 was considered suitable for favourable environments.

Singh and Nanda (1997) evaluated 20 greengram genotypes for yield performance in seven locations during 1994. There was significant genotype x environment interaction. Genotypes MGG-379 and LGG-460 gave the most stable yields compared to other genotypes. Both linear and non-linear components of G x E interaction contributed significantly to differences in stability among genotypes.

Manivannam *et al.* (1998) carried out phenotypic stability analysis in twelve greengram genotypes and evaluated them for seed yield and pods/plant at Pudukkottai, TamilNadu, during rabi 1992-94. Genotypes EC-310277, NIC-7915 and KM-2 showed good stability for both characters, while Vamban-1, EC 31027-7 and NIC-7915 gave the high yields (773, 655 and 732 kg/ha, respectively).

CHAPTER - III

MATERIALS AND METHODS

CHAPTER - III

MATERIALS AND METHODS

The details of materials used and the techniques adopted during the course of investigation are described in this chapter.

3.1 Experimental details

For the present investigation, three locations were selected as macro environments viz., Experimental Farm, College of Agriculture, Indore, Krishi Vigyan Kendra, Dhar and Krishi Vigyan Kendra, Jhabua. These locations are situated between 74°47' E to 75°91' E longitude and 22°54' N to 22° 87' N latitude and belong to two agro climatic zones viz., Malwa Plateau (Indore and Dhar) and Jhabua Hills (Jhabua).

The experimental material consisted of ten varieties of blackgram obtained from Regional Research Scheme on Pulses, College of Agriculture, Indore, where these varieties were either collected from different places of India or developed at the centre. These varieties along with their source/pedigree have been presented in Table 1.

Table 1 List of varieties studied

SN	Varieties	Source/pedigree
1	IU* 8-6	K-8219 x RU-2
2	IU 83-4	Type-9 x PDU-102
3	IU 83-2	Type-9 x PDU 102
4	IU 31-7	UG-157 x PS-1
5	TPU-4	VM-201 x Type-9 (BARC variety)
6	Type-9	Local selection from Kanpur
7	JU**-3	JU 77-1
8	JU-2	PDU-104 x PDU-1
9	IU 88-10	PDU-104 x PPDU-1
10	IU 84-9	Type-9 x LBG-20

*IU = Indore urid, ** JU = Jawahar urid

The material was planted at each of these locations in randomized block design with three replications. The gross plot size was 9.6 sq m (4 m x 2.4 m) with 8 rows and the net plot size was 6.3 sq m (3.5 m x 1.8 m) with 6 rows. The row to row and plant to plant distance was 30 cm and 10 cm, respectively. The crop was sown on 29th June, 2002 at Indore, on 26th June, 2002 at Dhar and on 27th June, 2002 at Jhabua. The crop was grown with a recommended dose of 20 kg N and 50 kg P_2O_5 per ha at each location. Plant protection measures were applied as per schedule and level of infestation. One spray of Endosulphan @ 2 ml/l of water at 10 days after sowing, one spray of Monocrotophos @ 1 ml/l of water at 30-35 days after sowing and one spray of Quinalphos @ 2 ml/l of water at 40-45 days after sowing, was applied at each location. At Indore, powdery mildew disease was observed and in order to control it, two sprays of Carbendazim @ 2 ml/l of water was applied at an interval of 15 days.

3.2 Environmental details of the site

Three locations, Indore, Dhar and Jhabua, belong to two different agro climatic regions. Indore belongs to Malwa Plateau region which is characterized by having rainfall of 600-1000 mm, low relative humidity with medium black soil; Dhar also comes under Malwa Plat eau region which receives 600-800 mm rainfall, having low relative humidity with red soil and Jhabua being a hilly region records an average of 600-700 mm rainfall with very low relative humidity and the soil is mostly shallow sandy to stony loam. This clearly indicates that the locations under study represented reasonably diverse agro climatic environments.

3.3 Meteorological details of each site

The meteorological conditions prevailed during the crop growth in these locations have been given in Table 2. It is evident from the weather data that precipitation recorded during crop period at Indore, Dhar and Jhabua was 646.50 mm, 657.28 mm and 735.20 mm, respectively. The

Table 2 Meteorological data of three locations during crop season (2002)

Location	Month	Average temperature (°C)		Average relative humidity	Total rainfall (mm)	No. of rainy days
		Minimum	Maximum			
Indore	June,02	30.68	39.49	71.62	115.64	9
	July, 02	25.71	31.42	66.43	88.90	6
	Aug., 02	22.93	28.29	69.80	342.40	19
	Sept., 02	22.37	31.02	68.29	99.56	10
Dhar	June,02	29.32	40.60	73.30	126.30	8
	July, 02	24.61	30.73	67.89	100.32	6
	Aug., 02	23.76	29.10	66.41	312.00	18
	Sept., 02	23.68	31.21	67.10	118.66	9
Jhabua	June,02	26.41	38.60	72.80	154.00	8
	July, 02	24.10	32.31	67.50	122.40	5
	Aug., 02	23.16	29.54	68.22	299.20	21
	Sept., 02	24.00	30.23	69.91	159.60	5

rainfall at all the three locations was normal. The maximum and minimum temperature recorded during crop period was 39.49°C and 22.37°C at Indore, 40.60°C and 23.68°C at Dhar and 38.60°C and 23.16°C at Jhabua, respectively. The total number of rainy days during crop period at Indore, Dhar and Jhabua was 44, 41 and 39 days respectively.

3.4 Observations recorded

In order to record the observations, five competitive plants were selected from each plot in each replication in each location. The following observations were recorded on each selected plant, except for days to 50% flowering and days to maturity, which were recorded on plot basis.

Fig. 1 Minimum temperature during crop season under three locations

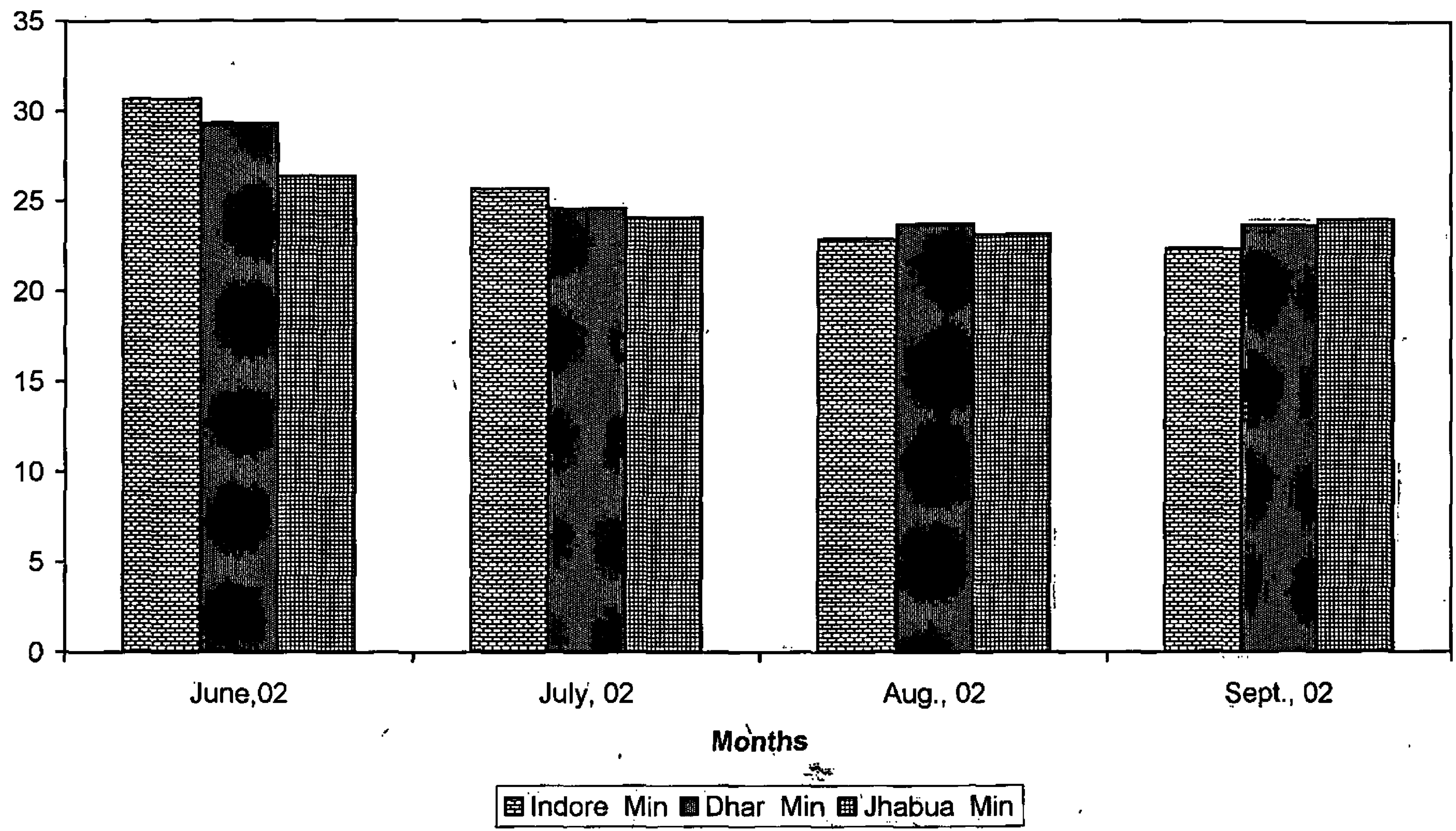


Fig. 2 Maximum temperature during crop season under three locations

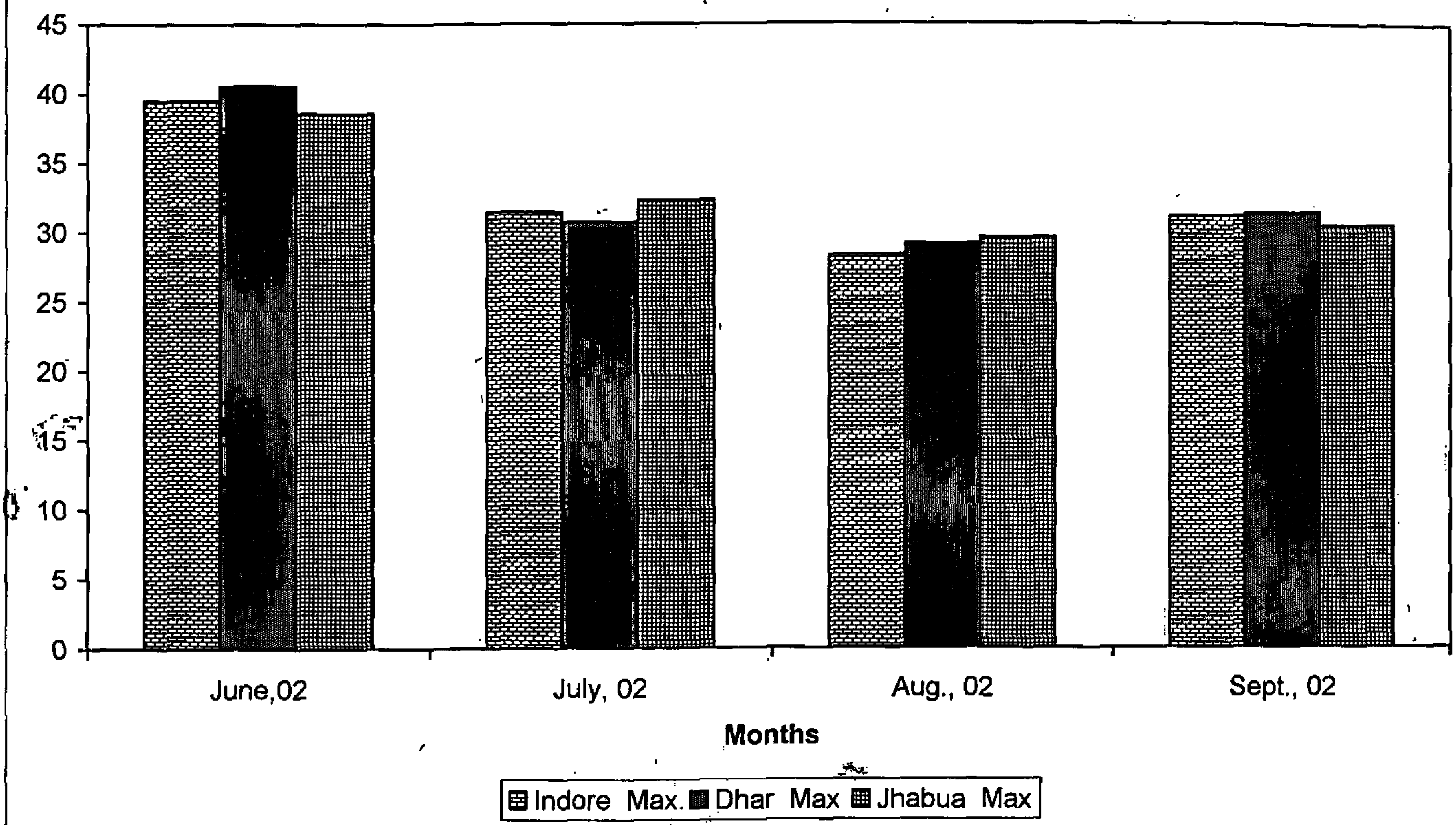


Fig. 3 Average relative humidity during crop season under three locations

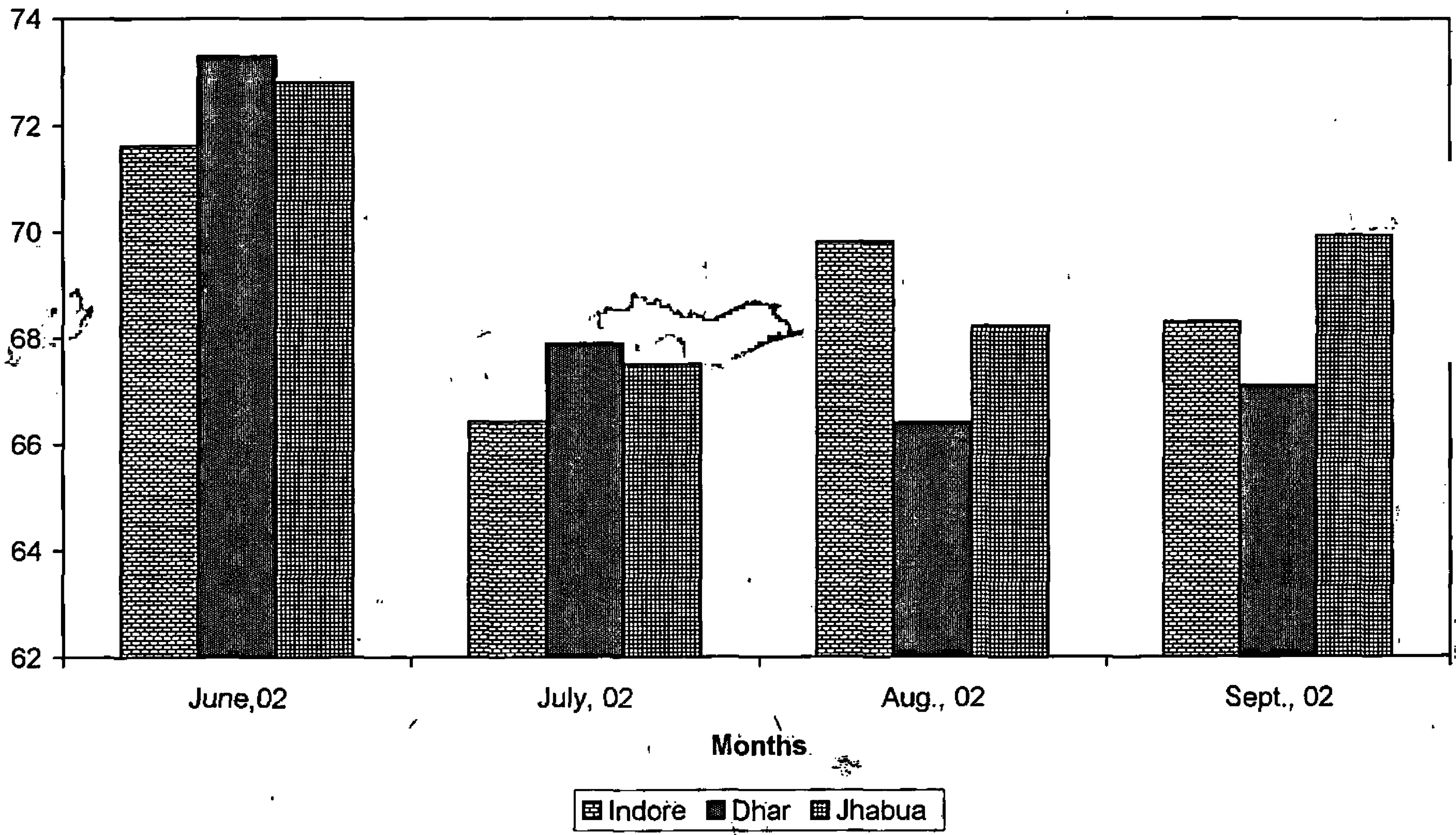


Fig. 4 Total rainfall during crop season under three locations

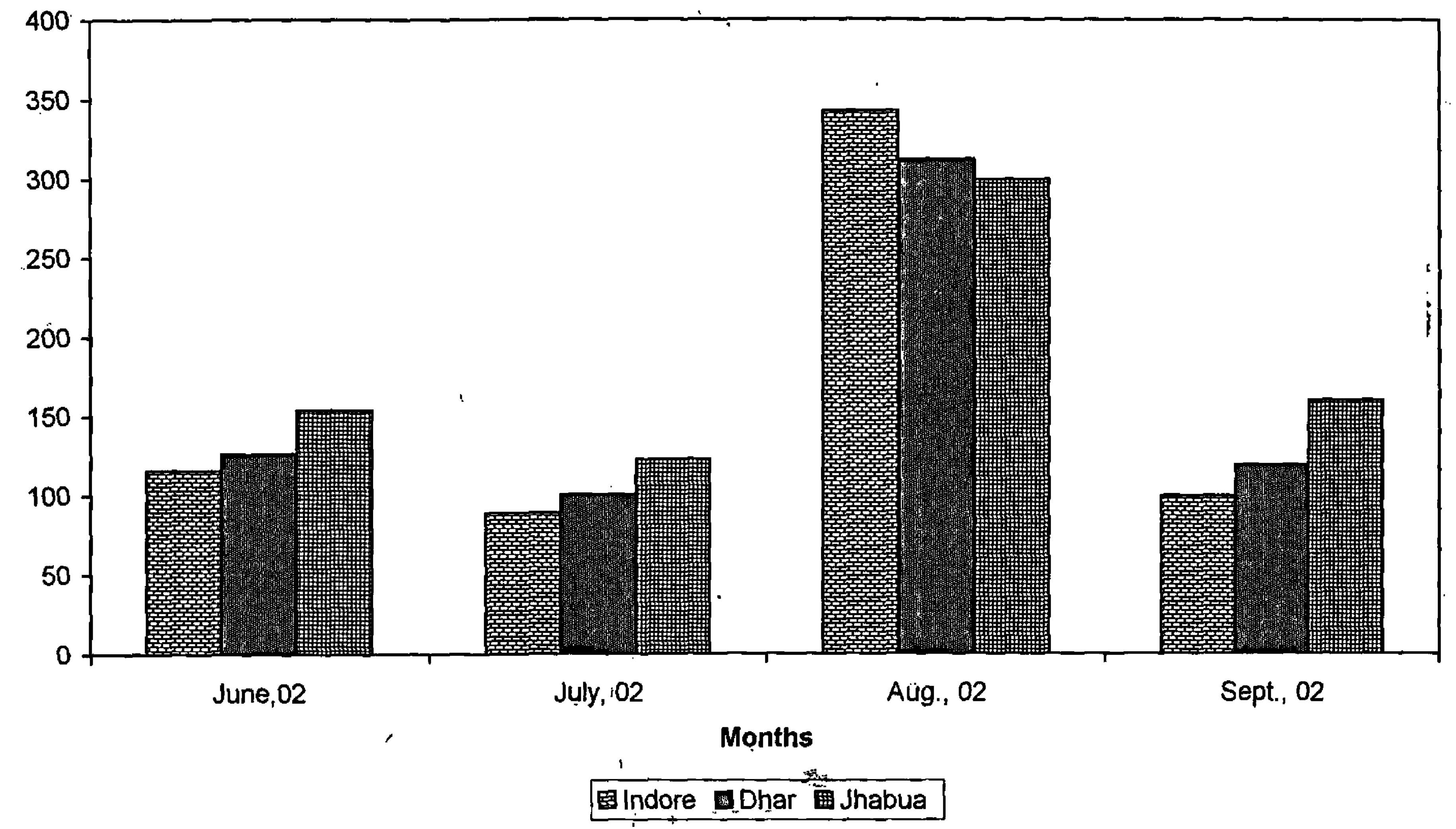
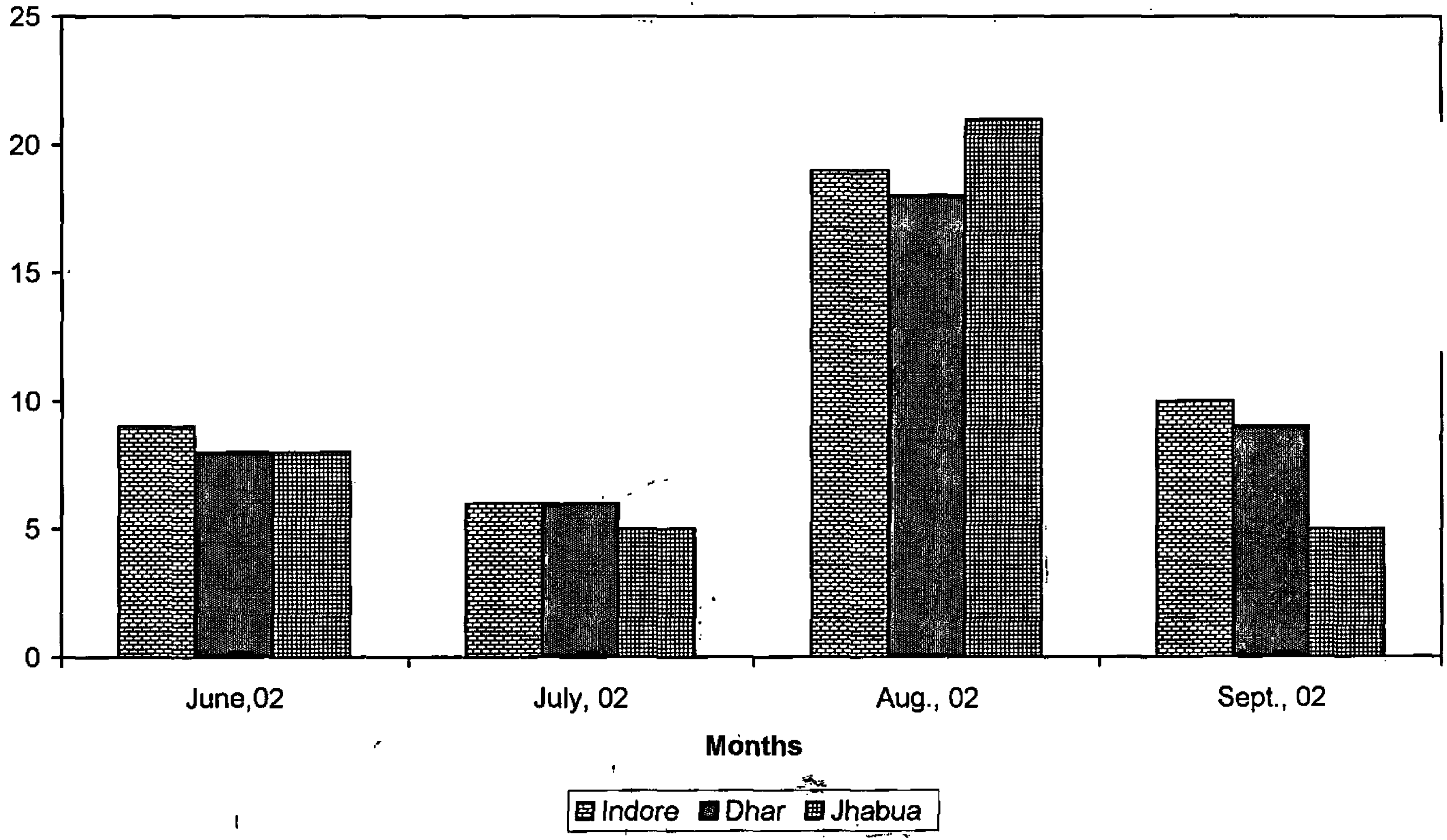


Fig. 5 Total number of rainy days during crop season under three locations



(i) Days to 50% flowering

The period from the date of planting to the date when 50 per cent of the plants in a plot were in bloom was recorded and expressed in number of days.

(ii) Days to maturity

The period from the date of sowing to the date of physiological maturity was recorded and expressed in number of days.

(iii) Plant height (cm)

The height of the plant was recorded in cm from the ground level to the tip of the main stem at the time of maturity.

(iv) Number of primary branches per plant

The number of primary branches borne on the main stem was recorded at maturity.

(v) Number of secondary branches per plant

The number of secondary branches borne on the primary branches was recorded at maturity.

(vi) Number of pods per plant

The effective number of pods per plant was counted at the time of harvest.

(vii) Number of seeds per plant

Total pods per plant were threshed and only healthy seeds were counted.

(viii) Number of seeds per pod

The ratio of number of seeds to the number of pods per plant was calculated to obtain seeds per pod.

(ix) 100-seed weight (g)

One hundred seeds drawn randomly were weighed in gram and the seed weight was recorded.

(x) Seed yield per plant (g)

Total seeds per plant were weighed in g.

(xi) Biological yield per pant (g)

The total dry weight (seed yield + weight of straw) per plant was recorded in g.

(xii) Harvest index

The harvest index was calculated by using the following formula:

$$\text{Harvest Index} = \frac{\text{Economic yield}}{\text{Biological yield}}$$

Statistical analysis

The data obtained from five plants were averaged to get mean per plant. These means were subjected to location wise analysis of variance followed by pooled analysis. The data were analysed for the design of experiment following the standard procedure given by Panse and Sukhatme (1967).

Analysis of variance

The mean values for each character of individual variety were based on competitively selected five plants from each replication for computation of environment wise analysis. The skeleton of ANOVA is presented below:

SN	Source of variation	Df	Mean squares	Expectation of mean squares
1.	Replications	2		
2.	Genotypes	9	M_1	$\sigma_e^2 + r\sigma_g^2$
3.	Error	18	M_2	σ_e^2

Pooled analysis of data

One of the requirements before we pool the data to perform pooled analysis over locations was testing homogeneity of error variances. For testing homogeneity Barlett's test was used as follows:

Let there be n mean squares, S_1^2, S_2^2 .... S_n^2 based on K_1, K_2 .... Kr degree of freedom. From these values a pooled estimate of variance ($\bar{S}^2$) was calculated:

$$\bar{S}^2 = \frac{1}{\sum_{n}^{n} Kr}\left(\sum_{1}^{n} Kr.S_n^2\right)$$

Next, the quantity X'^2 was calculated

$$X'^2 = \left(\sum_{1}^{n} Kr\right)\log_e \bar{S}^2 - \sum_{1}^{n} Kr \log_e S_n^2$$

For convenience, the logarithm was taken to the base 10 and the result was multiplied by $\log_e 10$ that is 2.3026 to get the quantity X'^2. The X'^2 is distributed approximately as X^2 with (n-1) degree of freedom, but is slightly biased upwards. This was corrected by dividing it with the correction factor:

$$C = 1 + \frac{1}{3(n-1)}\left\{\sum_{1}^{n}\frac{1}{Kr} - \frac{1}{\sum_{1}^{n} Kr}\right\}$$

The quantity X'^2/C was then referred to the X^2 table with (n-1) degree of freedom. Significance of X'^2 suggested that the error mean squares were heterogeneous and vice versa.

The data from the three locations were pooled only if the error mean squares are homogeneous to estimate the genotype x environment interaction. The ANOVA for combined analysis of variance is given below:

SN	Source of variation	df	MSS	Expectation of MSS
1.	Locations (l)	2		
2.	Genotypes	9	M_{11}	$\sigma_e^2 + r\sigma_{gl}^2 + rl\sigma_g^2$
3.	G x L	18	M_{12}	$\sigma_e^2 + r\sigma_{gl}^2$
4.	Error	54	M_{13}	σ_e^2

r = Number of replication, l = Number of locations

The mean sum of squares due to genotypes and environments were tested against mean sum of squares due to genotypes x environments. The mean sum of squares due to genotypes x environments were tested against pooled error.

Estimation of pooled error

The mean sum of squares due to error obtained in each individual environment were utilized and pooled error was calculated as follows:

$$\text{Pooled error} = \frac{(n_1-1)\,(\text{M.S. error } Y_1) + \text{----} \,(n_y-1)\,(\text{M.S. error } Y_y)}{(n_1-1) + (n_2-1) + \text{-----------------------} \,(n_y-1)}$$

Where,

n_1 -1	=	error degree of freedom in first environment.
n_y - 1	=	error degree of freedom in y^{th} environment,
M.S. error Y_1	=	M.S.S. due to error for 1^{st} environment, and
M.S. error Y_y	=	M.S.S. due to error for y^{th} environment

However, the pooled analysis was carried out on the basis of plot means where each and every value was the mean of three observations, one from each replication; thus the pooled error which was to be used to test the significance of variance due to varieties x environments was further divided by number of replications. In case the mean sum of squares due to varieties x environments were found significant, the analysis was further proceeded for the estimation of stability parameters.

Analysis for stability parameters

Stability analysis was done for those characters which manifested significant genotype x location interaction. For this purpose following model proposed by Eberhat and Russell (1966) was used:

$$Y_{ij} = \mu_i + b_i.I_j + \delta_{ij} + e_{ij}$$

Where,

Y_{ij}	=	The mean of i^{th} variety in j^{th} location
		(I = 1, 2.......v and j =1, 2.........n)
μ_i	=	The mean of i^{th} variety over all the locations.

b_i = Regression coefficient that measures the response of the i^{th} variety in varying environments.

I_j = Environmental index for j^{th} location, which is defined as the deviation of the mean of all the varieties for given environment from the overall mean i.e.

$$I_j = \left(\sum_i \frac{Y_{ij}}{v}\right) - \left(\frac{\sum_i \sum_j Y_{ij}}{vn}\right) \qquad \sum_j I_j = 0$$

and,

δ_{ij} = The deviation from regression of the i^{th} variety in j^{th} environment.

e_{ij} = Error associated with each observation.

Stability parameters

The parameters of stability were calculated as below:

(a) The regression coefficient which is the regression of the performance of each variety under different environments on the environmental means overall the genotypes was estimated as follows:

$$b_i = \frac{\sum_j Y_{ij}.I_j}{\sum_j I_j^2}$$

where,

$\sum_j Y_{ij}.I_j$ = The sum of product between variety and environmental index,

and

$\sum_j I_j^2$ = The sum of squares of all the environmental indices.

To obtain bi values for all varieties following matrix as suggested by Singh and Choudhary (1977) was used.

$[\bar{X}]\,[I_j] = [Y_{ij}\, I_j] = [S]$

where,

$[\bar{X}]$ = Matrix of means

$[I_j]$ = Vector for environmental index

$[S]$ = Vector for sum of products i.e. $\sum_j Y_{ij}.I_j$

(b) The other parameter to estimate stability of the varieties was a function of squared deviations form regression (S_{di}^2) which was estimated as follows:

$$S_{di}^2 = \left[\frac{\sum_j \delta_{ij}^2}{n-2}\right] - \left[\frac{S_e^2}{r}\right]$$

Where,

$$\sum_j \delta^2_{ij} = \left[\frac{\sum_j Y_{ij}^2 - Y_i^2}{n}\right] - \frac{\left(\sum_j Y_{ij}.I_j\right)^2}{\sum_j I_j^2}$$

and S_e^2 = The estimate of pooled error (or the variance of the variety mean of j^{th} location)

Table 3 Skeleton of analysis of variance for stability analysis as per the Eberhart and Russell's stability model (1966).

SN	Source	df	SS	MS
1	Varieties (v)	v-1	$\frac{1}{n}\sum_i Y_i^2 - CF$	MS1
2	Environment + (varieties x environment)	v(n-1)	$\frac{\sum_i\sum_j Y_{ij}^2 - \sum_i Y_i^2}{n}$	
3	Environment (linear)	1	$\frac{1}{v}\frac{\left(\sum_j Y_{ij}.I_j\right)^2}{\sum_j I_j^2}$	
4	Variety x Environment (linear)	v-1	$\sum_i \frac{\left[\sum_j Y_{ij}.I_j\right]^2}{\sum_j I_j^2} - Environ.(linear)SS$	MS2
5	Pooled deviations	v(n-2)	$\sum_i\sum_j \delta_{ij}^2$	MS3
	Variety 1	(n-2)	$\left[\sum_j Y_{1j}^2 - \frac{Y_1^2}{n}\right] - \left[\frac{\left(\sum_j Y_{1j}.I_j\right)^2}{\sum_j I_j^2}\right] = \sum_j \delta_{1j}^2$	
	Variety 2	(n-2)	……	
	……….	……	……	
	…..	……	……	
	Variety v	n-2	$\left[\sum_j Y_{vj}^2 - \frac{Y_v^2}{n}\right] - \left[\frac{\left(\sum_j Y_{vj}.I_j\right)^2}{\sum_j I_j^2}\right] = \sum_j \delta_{vj}^2$	
6	Pooled error	n(r-1) (v-1)		MS4
7	Total	nv-1	$\sum_i\sum_j Y_{ij}^2 - CF$	

Here, v = number of varieties

n = number of environments

The skeleton for appropriate analysis of variance proposed by *Eberhart and Russell (1966) has been presented in Table 3. In this model* Environment + (Variety x Environment) sum of square were partitioned into:

(i) Environments (*linear*)

(ii) Variety x Environments (linear)

(iii) Pooled deviation

Significance for the environment (linear) indicates significant differences among the locations. Significance of variety x environment (linear) suggests that the b_i values of different varieties are significantly different from each other. Significance of pooled deviations indicates that the varieties deviated from their b_i values at different locations.

CHAPTER - IV

EXPERIMENTAL FINDINGS

CHAPTER – IV

EXPERIMENTAL FINDINGS

The experimental results on data determining the stability performance of 10 blackgram varieties under three locations of Madhya Pradesh viz., Indore, Dhar and Jhabua and over locations have been summarized under the following heads:

4.1 Analysis of variance

4.2 Pooled analysis of variance

4.3 Analysis of variance for stability parameters as per the Eberhart and Russell's stability model (1966)

4.4 Estimation of stability parameters

4.5 Stability of traits

4.1 Analysis of variance

The analysis of variance (Table 4) was carried out for 12 characters viz., days to 50 per cent flowering, days to maturity, plant height (cm), number of primary branches per plant, number of secondary branches per plant, number of pods per plant, number of seeds per plant, 100-seed weight (g), seed yield per plant (g), biological yield per plant (g) and harvest index for each location separately. The data of Table 4 showed that the variance due to varieties were highly significant for days to 50 per cent flowering (4.741), days to maturity (29.500), plant height (122.389), number of primary branches per plant (6.284) and number of secondary branches per plant (4.879) and it was found significant for 100-seed weight (0.335), while non-significant for number of pods per plant (42.480), number of seeds per plant (1818.200), number of seeds per pod (0.872), seed yield per plant (1.458), biological yield per plant (32.632) and harvest index (526.063), at Indore.

Table 4 Analysis of variance for various characters in blackgram for each location (mean sum of square)

Location	Source of variation	d.f.	Days to 50 % flowering	Days to maturity	Plant height (cm)	No. of primary branches/ plant	No. of secondary branches/ plant	No. of pods/ plant	No. of seeds/ plant	No. of seeds/ pod	100 seed weight (g)	Seed yield/ plant (g)	Bio-logical yield/ plant (g)	Harvest index (%)
Indore	Replication	2	0.300	0.536	19.324	3.761*	11.397**	42.177	666.934	0.308	0.069	2.263	15.350	402.332
	Varieties	9	4.741**	29.500**	122.389**	6.284**	4.879**	42.480	1818.200	0.872	0.335*	1.458	32.632	526.063
	Error	18	0.374	0.311	10.986	0.853	1.209	27.117	864.058	0.374	0.096	1.707	21.141	314.574
Dhar	Replication	2	0.434	0.034	16.919	1.941	6.885	12.766	560.195	0.409	0.031	1.049	13.418	115.699
	Varieties	9	6.448**	30.608**	27.417	3.112	7.142*	47.680	1567.721	0.858**	0.082	3.734	24.957	440.404
	Error	18	0.248	0.329	37.667	2.301	2.839	46.052	1594.449	0.209	0.085	2.744	14.937	295.248
Jhabua	Replication	2	1.033	0.900	12.414	0.964	2.628*	3.691	287.746	0.084	0.062	0.902	0.139	23.794
	Varieties	9	19.515**	46.741**	398.669**	8.757**	3.786**	68.449**	3237.011**	0.539**	0.112	1.899	24.365	25.775
	Error	18	0.404	0.641	14.652	0.417	0.715	11.749	421.308	0.047	0.061	2.211	10.019	94.882

* Significance at 5 per cent

** Significance at 1 per cent

At Dhar, the variance due to varieties were highly significant for days to 50 per cent flowering (6.448), days to maturity (30.608) and number of seeds per pod (0.858), it was found significant for number of secondary branches per plant (7.142) and non-significant for all other traits studied.

At Jhabua, the variance due to varieties were highly significant for almost all the traits except for 100-seed weight (0.112), seed yield per plant (1.899), biological yield per plant (24.365) and harvest index (25.775), for which it was non-significant.

4.2 Pooled analysis of variance

Prior to carry out the pooled analysis of variance, the test of homogeneity of error variances of three locations was applied for each character by utilizing the Bartlett's method (1937). The estimated X^2 values (chi square values) were non-significant at 5 per cent probability level for all the 12 characters, which suggested that error mean squares at different locations were homogeneous and therefore pooled analysis could be done.

The pooled analysis of variance (Table 5) revealed that the differences among the genotypes in pooled data were highly significant for days to 50 per pent flowering (8.677), days to maturity (31.632), plant height (120.64) and number of primary branches per plant (3.990) and significant for number of seeds per pod (0.581). While for other characters under study, differences among the genotypes were non-significant. Further it was observed that the differences among the locations were highly significant for plant height (244.951), number of pods per plant (306.667), number of seeds per plant (11529.24) and 100-seed weight (0.425). While it was significant for days to maturity (9.657) and number of primary branches per plant (4.443). The differences among the locations were non-significant for all other traits under study. The mean sum of squares due to

Table 5 Pooled analysis of variance for various characters in blackgram (mean sum of squares)

Source of variation	d.f.	Days to 50 % flowering	Days to maturity	Plant height (cm)	No. of primary branches/ plant	No. of secondary branches/ plant	No. of pods/ plant	No. of seeds/ plant	No. of seeds/ pod	100 seed weight (g)	Seed yield/ plant (g)	Bio-logical yield/ plant (g)	Harvest index (%)
Environments	2	8.677**	31.632**	120.640**	3.990**	2.835	28.473	1185.130	0.581*	0.76	1.723	14.221	110.285
Varieties	9	2.361	9.657*	244.951**	4.443*	2.059	306.667**	11529.24**	0.023	0.425**	2.142	6.887	211.958
Var. x Env.	18	0.779*	1.993*	31.093	1.030	1.217	12.198	511.258	0.087	0.050	0.320	6.548	110.231
Pooled error	54	0.342	0.427	21.102	1.191	1.588	28.306	959.938	0.209	0.081	2.221	15.366	234.901

* Significance at 5 per cent

** Significance at 1 per cent

genotype x environment interaction were highly significant for days to maturity (1.993) and significant for days to 50 per cent flowering (0.779), while for all other traits under study, it was found non-significant.

4.3 Analysis of variance for stability parameters as per the Eberhart and Russell's stability model (1966)

Genotype x environment interaction was found non-significant for all the major yield contributing traits as well as for seed yield. However, for only two traits viz., days to 50 per cent flowering and days to maturity it was found significant. Hence, the Eberhart and Russell's phenotypic stability model (1966) was applied to determine the stability parameters for these two characters only.

The response of the variety to the changing environment is measured by the environment (linear) effect, which was highly significant for both the characters i.e. days to 50 per cent flowering (4.718) and days to maturity (19.341). the mean sum of squares due to varieties x environments (linear) were highly significant for days to maturity (3.819) and were found non-significant for days to 50 per cent flowering (1.051). The pooled deviations were found highly significant for days to 50 per cent flowering (0.456) and were non-significant for days to maturity (0.148) (Table 6).

Table 6 Analysis of variance for stability parameters as per Eberhart and Russell's stability model (1966)

Source of variation	d.f.	Days to 50% flowering	Days to maturity
Varieties	9	8.677**	31.632**
Environments	2	2.361	9.657*
Var. x Env.	18	0.779*	1.993**
Env. (linear)	1	4.718**	19.341**
Var. x Env. (linear)	9	1.051	3.819
Pooled deviation	10	0.456**	0.148
Pooled error	54	0.342	0.427

*Significant at 5 per cent **Significant at 1 per cent

4.4 Estimation of stability parameters

The stability parameters i.e. (i) mean, (ii) regression coefficient and (iii) deviation from regression are required to be estimated for determining the stability of traits, over locations. For determining the regression coefficient, the environmental index needs to be estimated. The data boxed in Table 7 indicated that the values of environmental index at Indore were positive for both characters, days to 50 per cent flowering (0.512) and days to maturity (0.713).

Table 7 Environmental indices for various characters in chickpea

SN	Characters	Indore	Dhar	Jhabua
1.	Days to 50% flowering	0.512	-0.055	-0.456
2.	Days to maturity	0.713	0.411	-1.22

At Dhar, the value of environmental index was found positive for days to maturity (0.411) and negative for days to 50 per cent flowering (-0.055).

At Jhabua both the traits viz., days to 50 per cent flowering (-0.456) and days to maturity (-1.122) possessed negative value of the same.

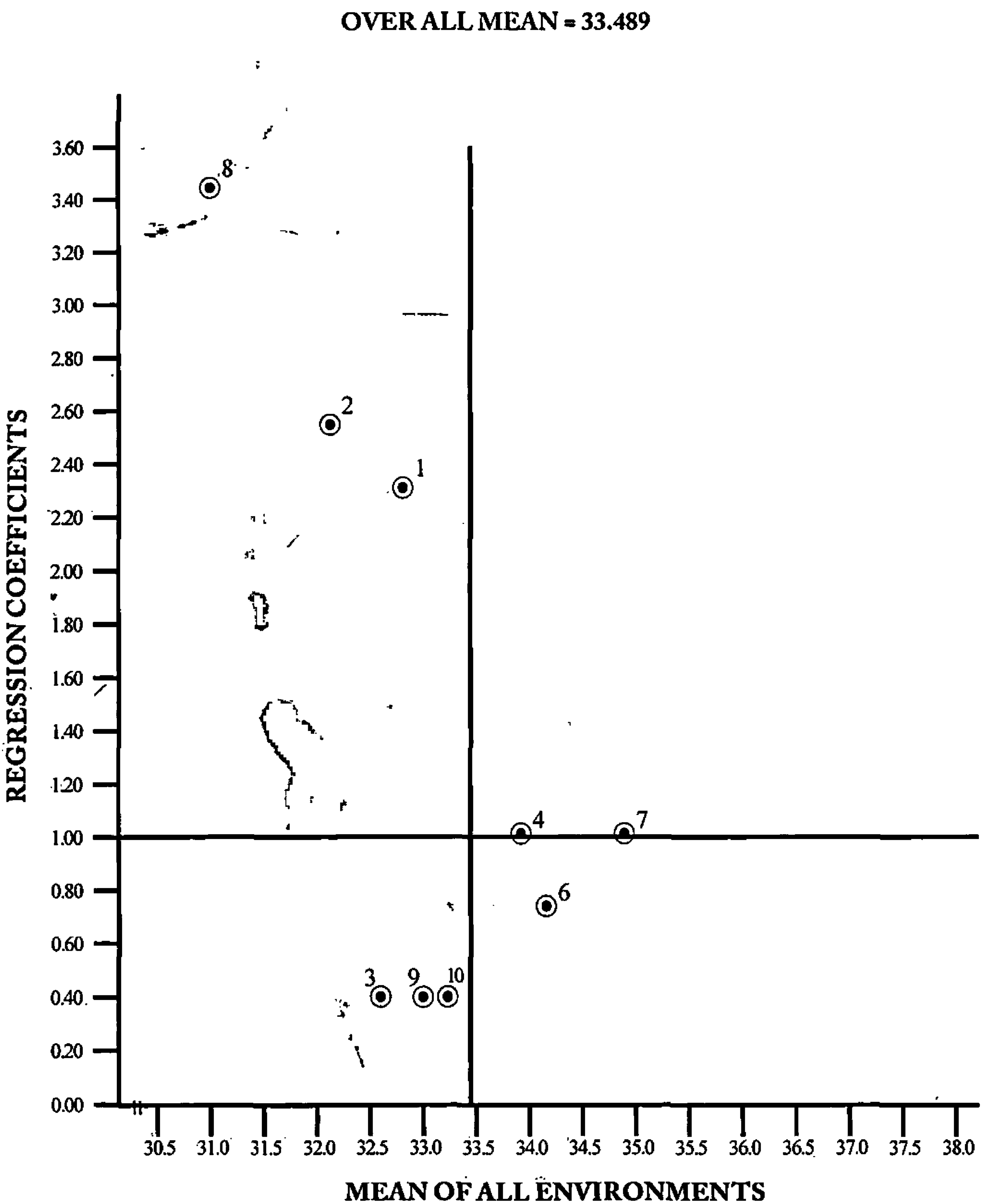
The stability parameters i.e. (i) mean, (ii) regression coefficient and (iii) deviation from regression were computed and have been discussed character wise hereunder. Also, the distributions of the genotype on the basis mean and regression values in different quadrants for different characters have been illustrated in Fig.1 and 2.

4.4.1 Days to 50 per cent flowering

The grand mean value for this trait was 33.489.

The genotypes viz., IU 83-2, IU 88-10 and IU 84-9 possessed regression coefficient less than unity i.e. (0.40), (0.40) and (0.04)

Fig. 6 Stability performance of genotypes for days to 50% flowering



respectively with lower means than the grand mean, 32.67, 33.00 and 33.22, respectively. These varieties exhibited low magnitude of deviation from regression (0.03), (0.03) and (-0.04) respectively.

Varieties IU 8-6, IU 83-4 and JU-2 possessed regression coefficients more than unity (2.29), (2.57) and (3.41), respectively and they exhibited lower mean values than the grand mean value, 32.78, 32.11 and 31.00, respectively. Varieties IU 8-6 and JU-2 exhibited low values of deviation from regression, (0.59) and (-0.06) respectively, but variety IU 83-4 had high value of deviation from regression (1.50).

Varieties IU 31-7, TPU-4 and JU-3 with regression coefficients more than unity, (1.01), (-1.89) and (1.01) respectively were associated with higher mean values than the grand mean value, 33.89, 37.22 and 34.89, respectively. Varieties IU 31-7 and JU-3 exhibited low magnitude of deviation from regression (-0.07) each, while variety TPU-4 exhibited high value of deviation from regression (1.38).

Variety Type-9, with regression coefficient of (0.76) was found to be associated with higher mean value (34.11) than the grand mean and possessed low value of deviation from regression (0.13).

4.4.2 Days to maturity

The grand mean value for this trait was 77.122.

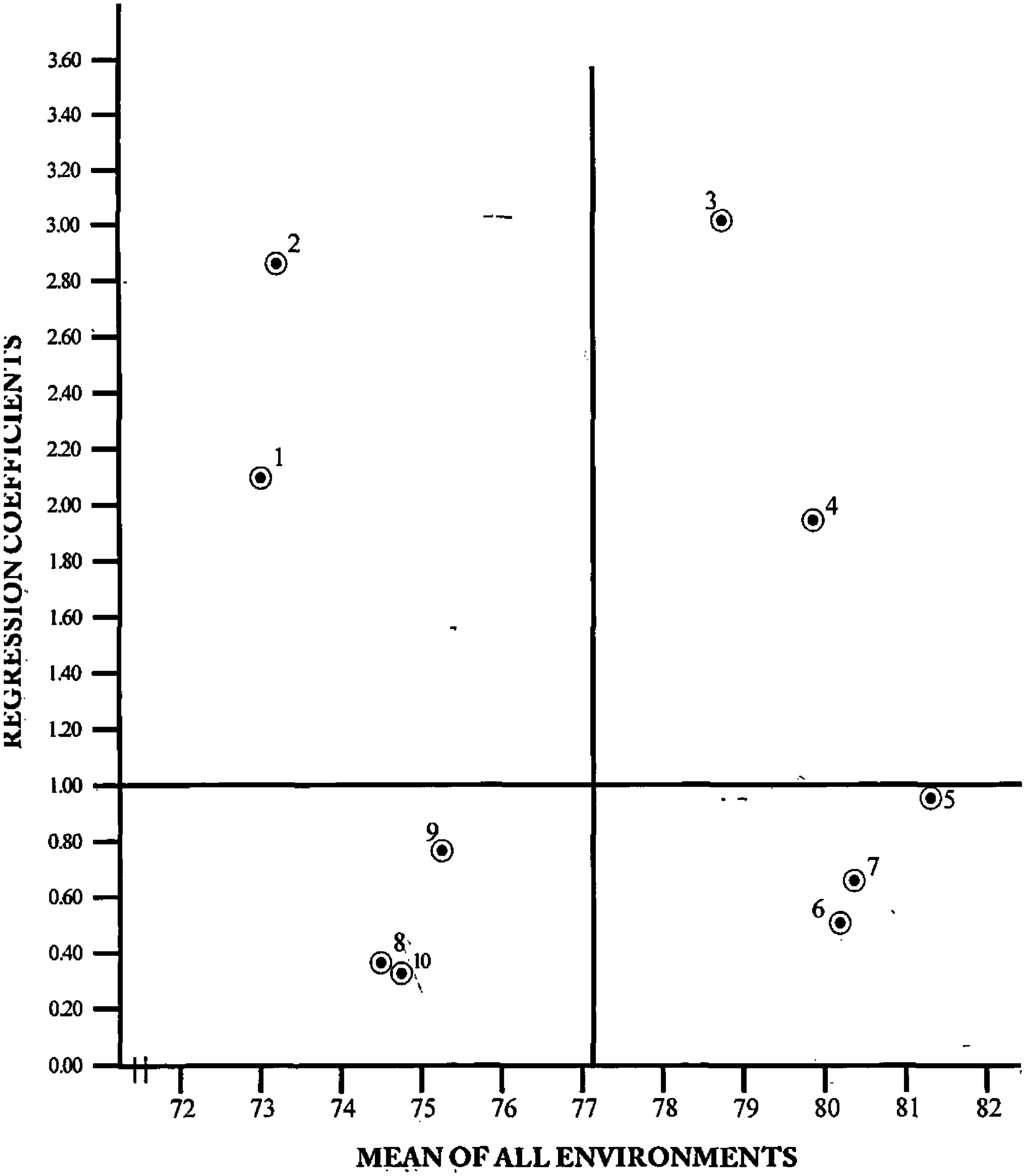
Varieties JU-2, IU 88-10 and IU 84-9 possessed regression coefficients of less than unity (0.37), (-0.77) and (0.33), respectively and were found to be associated with lower mean values, 74.67, 75.11 and 74.78 respectively, than the grand mean. They also exhibited low values of deviation from regression (0.26), (-0.12) and (0.16) respectively.

Varieties IU 8-6 and IU 83-4 possessed values of regression coefficient more than unity (2.11) and (2.83), respectively, and associated with lower means, 73.00 and 73.22 respectively. They exhibited low magnitude of deviation from regression (-0.07) and (0.01), respectively.

The stability parameters presented in Table 8 revealed that varieties IU 83-2 and IU 31-7 possessed high regression coefficients of

Fig. 7 Stability performance of genotypes for days to maturity

OVER ALL MEAN = 77.122



(3.02) and (1.93) respectively and associated with higher means than the grand mean, 78.78 and 79.89, respectively. They had low magnitude of deviation from regression (0.03) each.

Table 8 Stability parameters for various characters in blackgram

SN	Varieties	Days to 50% flowering			Days to maturity		
		X	b	S^2d	X	b	S^2d
1	IU 8-6	32.78	2.29	0.59	73.00	2.11	-0.07
2	IU 83-4	32.11	2.57	1.50	73.22	2.83	0.01
3	IU 83-2	32.67	0.40	0.03	78.78	3.02	0.03
4	IU 31-7	33.89	1.01	-0.07	79.89	1.93	0.03
5	TPU-4	37.22	-1.89	1.38	81.22	-0.97	-0.10
6	Type-9	34.11	0.76	0.13	80.22	0.51	-0.12
7	JU-3	34.89	1.01	-0.07	80.33	0.63	-0.02
8	JU-2	31.00	3.41	-0.06	74.67	0.37	0.26
9	IU 88-10	33.00	0.40	0.03	75.11	-0.77	-0.12
10	IU 84-9	33.22	0.40	-0.04	74.78	0.33	0.16
	Mean	33.489			77.122		

Three varieties TPU-4, Type-9 and JU-3 possessed regression coefficient less than unity (-0.97), (0.51) and (0.63), respectively, and were found to be associated with higher mean values, 81.22, 80.22 and 80.33, respectively. They exhibited low magnitude of deviation from regression (-0.10), (-0.12) and (-0.02), respectively (Table 8).

4.5 Stability of traits

As evident by Table 9 the traits namely number of primary branches/plant, number of secondary branches/plant, number of pods/plant, number of seeds/pod, 100-seed weight (g) and seed yield per *plant (g) showed the least variation over locations (on the basis of mean performance). Hence, these are regarded as stable traits i.e. their expression was least affected by the location/environment. The mean values for number of primary branches per plant were 8.35, 8.07 and 9.34;*

for number of secondary branches per plant. 5.79; 5.92 and 5:08; for number of pods per plant 22.35, 20.35 and 21.47; for number of seeds per pod 6.17, 6.25 and 6.16; for 100-seed weight (g) 4.82, 5.08 and 4.88, and for seed yield per plant (g) 6.50; 6.38 and 6.39 under Indore, Dhar and Jhabua conditions, respectively.

Table 9 Mean values of traits in each location

SN	Characters	Indore	Dhar	Jhabua
1	Days to 50 per cent flowering	34.00	32.43	33.03
2	Days to maturity	77.84	77.53	76.00
3	Plant height (cm)	34.31	35.48	43.41
4	No. of primary branches/plant	8.35	8.07	9.34
5	No. of secondary branches/plant	5.79	5.92	5.08
6	Number of pods/plant	22.35	20.35	21.47
7	Number of seeds/plant	139.95	126.57	131.71
8	Number of seeds/pod	6.17	6.25	6.16
9	100-seed weight (g)	4.82	5.08	4.88
10	Seed yield/ plant (g)	6.50	6.38	6.39
11	Biological yield/plant (g)	17.51	15.45	17.09
12	Harvest index	37.59	42.76	37.78

On the basis of *per se* performance of the varieties (Table 10), the relative ranking of varieties for various characters at Indore was as follows. For days to maturity IU 8-6 (74.67), IU 88-10 (74.67) and IU 84-9 (74.67), for plant height JU-3 (43.13), TPU-4 (40.13) and IU 31-7 (40.00), for number of pods per plant IU 83-2 (29.80), JU-2 (25.93) and IU 31-7 (24.13), for 100 seed weight IU 83-4 (5.30), IU 31-7 (5.20) and TPU-4 (5.06), for seed yield per plant IU 83-2 (8.64), JU-2 (7.52) and Type-9 (7.05) and for harvest index JU-2 (52.29), JU-3 (44.16) and IU 83-2 (40.62).

At Dhar, the relative ranking of varieties for days to maturity was IU 8-6 (73.67), JU-2 (74.33) and IU 83-4 (74.67), for plant height IU 83-2 (40.80), IU 8-6 (38.00) and Type-9 (37.4), for number of pods per plant IU 83-2 (27.12), Type-9 (22.32) and IU 31-7 (21.85), for 100 seed weight IU 31-7 (5.30), IU 8-6 (5.20) and Type-9 (5.16), for seed yield per plant IU 83-2 (7.81), Type-9 (7.63) and JU-2 (7.14) and for harvest index JU-2 (61.00), IU-31-7 (51.19) and JU-3 (48.67).

At Jhabua, the relative ranking of varieties for days to maturity was IU 83-4 (70.00), IU 8-6 (70.67) and JU-2 (74.33), for plant height TPU-4 (58.27), Type-9 (56.67) and JU-3 (55.93), for number of pods per plant IU 83-4 (28.40), Type-9 (25.87) and IU 8-6 (24.07), for 100 seed weight IU 31-7 (5.14), IU 8-6 (5.07) and IU 88-10 (5.07), for seed yield per plant Type-9 (7.69), IU 83-2 (7.33) and IU 8-6 (6.84) and for harvest index IU 8-6 (45.63), IU 83-4 (41.37) and IU 31-7 (41.04).

Table 10 *Per se* performance of the varieties at Indore

SN	Variety	Days to 50% flower -ing	Days to maturity	Plant height (cm)	No. of primary branches per plant	No. of secondary branches per plant	No. of pods per plant	No. of seeds per plant	No. of seeds per pod	100 seed weight (g)	Seed yield per plant (g)	Biological yield per plant (g)	Harvest index
1	IU 8-6	33.67	74.67	31.07	7.13	5.07	21.87	134.73	6.16	5.00	6.73	18.97	35.47
2	IU 83-4	33.00	75.00	25.53	6.80	5.00	18.73	126.27	5.67	5.30	6.67	19.75	23.08
3	IU 83-2	33.00	80.67	39.80	10.20	7.00	29.80	172.93	5.80	5.00	8.64	21.27	40.62
4	IU 31-7	34.33	81.00	40.00	10.67	8.40	24.13	133.86	5.54	5.20	6.96	17.88	38.92
5	TPU-4	36.67	80.67	40.13	8.13	5.87	22.47	125.67	5.59	5.06	6.32	18.80	33.61
6	Type-9	34.67	80.67	36.80	9.80	6.20	23.67	160.33	6.77	4.40	7.05	19.40	36.29
7	JU-3	35.33	81.00	43.13	7.93	5.47	20.20	143.00	7.00	4.63	6.62	14.99	44.16
8	JU-2	32.67	75.33	26.27	8.80	6.27	25.93	173.73	6.70	4.33	7.52	14.38	52.29
9	IU 88-10	33.33	74.67	29.93	6.93	3.93	19.87	122.93	6.19	4.73	5.81	16.29	35.66
10	IU 84-9	33.33	74.67	30.40	7.06	4.67	16.87	106.07	6.28	4.53	4.80	13.39	35.84
	Mean	34.00	77.84	34.31	8.35	5.79	22.35	139.95	6.17	4.82	6.50	17.51	37.59

Table 10 *Per se* performance of the varieties at Dhar (contd....)

SN	Variety	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of primary branches per plant	No. of secondary branches per plant	No. of pods per plant	No. of seeds per plant	No. of seeds per pod	100 seed weight (g)	Seed yield per plant (g)	Biological yield per plant (g)	Harvest index
1	IU 8-6	33.33	73.67	38.00	7.93	5.53	20.13	126.33	6.27	5.20	6.57	19.66	33.41
2	IU 83-4	33.00	74.67	35.00	9.13	7.06	19.73	119.33	6.04	5.03	6.00	17.16	34.96
3	IU 83-2	30.33	80.67	40.80	10.20	8.93	27.13	152.53	5.62	5.13	7.81	18.80	41.54
4	IU31-7	31.00	81.00	35.80	8.27	5.86	21.85	125.67	5.75	5.30	6.62	12.93	51.19
5	TPU-4	33.33	80.67	35.07	7.60	4.67	17.54	116.13	6.62	4.70	5.34	11.25	47.28
6	Type-9	33.67	80.33	37.40	7.73	5.93	22.32	148.13	6.63	5.16	7.63	16.53	46.15
7	JU-3	33.00	80.33	35.87	6.33	3.67	18.57	125.87	6.81	5.10	6.40	13.91	48.67
8	JU-2	31.00	74.33	35.20	7.60	5.20	21.60	143.67	6.65	5.03	7.14	11.70	61.00
9	IU 88-10	32.67	74.67	30.87	8.06	7.53	18.74	108.33	5.78	4.93	5.32	16.26	32.71
10	IU 84-9	33.00	75.33	30.80	7.87	4.87	15.85	99.71	6.29	5.00	5.00	16.32	30.73
	Mean	32.43	77.53	35.48	8.07	5.92	20.35	126.57	6.25	5.08	6.38	15.45	42.76

Table 10 *Per se* performance of the varieties at Jhabua (contd….)

SN	Variety	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of primary branches per plant	No. of secondary branches per plant	No. of pods per plant	No. of seeds per plant	No. of seeds per pod	100 seed weight (g)	Seed yield per plant (g)	Biological yield per plant (g)	Harvest index
1	IU 8-6	31.33	70.67	35.25	7.47	6.33	24.07	135.16	5.62	5.07	6.84	14.99	45.63
2	IU 83-4	30.33	70.00	36.26	6.87	5.73	28.40	135.28	6.16	4.95	6.72	16.24	41.37
3	IU 83-2	32.67	75.33	47.67	11.67	6.13	23.80	147.40	6.20	4.97	7.33	18.29	40.04
4	IU 31-7	33.33	77.67	50.47	10.80	6.27	20.46	113.01	5.62	5.14	5.88	14.33	41.04
5	TPU-4	38.67	82.33	58.27	8.73	5.00	19.40	113.44	5.84	4.81	5.45	16.43	33.17
6	Type-9	34.00	79.67	56.67	11.80	5.73	25.87	155.82	6.80	5.06	7.69	23.75	32.43
7	JU-3	34.33	79.67	55.93	8.73	3.73	23.13	152.94	6.61	4.57	6.74	18.60	36.24
8	JU-2	29.33	74.33	33.47	10.20	4.60	21.80	142.62	6.54	4.63	6.57	17.50	37.54
9	IU 88-10	33.00	76.00	30.53	8.13	3.33	15.13	108.58	5.85	5.07	5.47	17.04	32.10
10	IU 84-9	33.33	74.33	29.53	9.00	3.93	12.67	112.85	6.39	4.57	5.24	13.69	38.27
	Mean	33.03	76.00	43.41	9.34	5.08	21.47	131.71	6.16	4.88	6.39	17.09	37.78

CHAPTER - V

DISCUSSION

CHAPTER – V

DISCUSSION

The main object of this experiment is to select genotypes which are consistently high yielders over a wide range of environments. When varieties are compared over a series of environments, their relative ranking usually differs. Varietal adaptability to environmental fluctuations is important for the stabilization of crop production both over regions and years. The importance of G x E interaction reflects the necessity of genotypes in more than a single environment.

Wide adaptability to various environmental conditions is very important in black gram genotypes, because they are excepted to be grown over a wide range of agro-ecosystems and depends on socio-economic status of the farmers. Thus, identification of stable black gram genotypes is important to increase the productivity. Also, it is well known that for a less favoured farmer, stability of crop production is more important than high yields based on high investments. Hence, a discussion on genotypes x environment interaction throws light on the magnitude of environmental effects on varietal adoptions and performance and thus helps to further the efficiency of breeding for well adapted varieties.

The ultimate goal of a plant breeder is to increase the genetic potential of a crop coupled with high yield. The identification of a genotype with high yield potential and least seasonal fluctuations over a wide range of environments is an important consideration in any crop improvement programme. This is true especially for the newly introduced high yielding varieties of black gram. Few attempts have been made to ascertain the extent of yield and its components. Information in this regards will enable the plant breeder to plan an effective breeding programme to synthesize agronomically superior genotypes with better nutritional quality. Hence, the present investigation namely "Adaptation analysis for yield and its attributes in black gram (*Vigna mungo* L. Hepper)," was conducted over three locations to evaluate the stability parameters using Eberhart and

Russell phenotypic stability model (1966), for twelve characters viz., days to 50 per cent flowering, days to maturity, plant height (cm), number of primary branches per plant, number of pods per plant, number of seeds per plant, number of seeds per pod, 100-seed weight (g), seed yield per plant (g), biological yield per plant (g) and harvest index.

The discussion pertaining to different aspects of the present investigation has been furnished under the following heads:

5.1 Analysis of variance.

5.2 Pooled analysis of variance.

5.3 Analysis of variance for stability parameters as per the stability model of Eberhart and Russell (1966).

5.4 Estimation of stability parameters.

5.5 Stability of traits.

5.1 Analysis of variance

The analysis of variance for 12 characters, at three locations showed that the variance due to varieties were highly significant for days to 50 per cent flowering, days to maturity, plant height, number of primary branches per plant and number of secondary branches per plant and significant for 100-seed weight at Indore.

At Dhar, the variance due to varieties were highly significant for days to 50 per cent flowering, days to maturity and number of seeds per pod and it was found significant for number of secondary branches.

At Jhabua, the variance due to varieties were highly significant for days to 50 per cent flowering, days to maturity, plant height, number of primary branches per plant, number of secondary branches per plant, number of pods per plant, number of seeds per plant and number of seeds per pod.

The above results showed that the mean sum of squares due to genotypes were highly significant for almost all the characters in three locations, indicating the presence of marked genetic variability among the experimental material under study. These results are in conformity with the findings of Singh et al. (1994), Chakraborty and Borua (1997) and Muduli and Hati (1994).

5.2 Pooled analysis of variance

The genotypes x environment interaction is of major consequence to the breeders in the process of evaluation of improved varieties. Genotype and environment may exhibit their interaction in several ways (Mather and Jinks, 1971). The failure of a genotype to give the same response in different environments is a definite indication of the presence of genotype-environment interaction.

Prior to carry out the pooled analysis of variance, the test of homogeneity of error variance of three locations was applied for each character by utilizing the Bartlett's method as appeared in Panse and Sukhatme (1967) and the error mean squares at different locations were found homogenous. The pooled analysis of variance revealed that the differences among the genotypes were significant for days to 50 per cent flowering, days to maturity, plant height, number of primary branches per plant, and number of seeds per pod, suggesting that the varieties under study exhibited genetic variation within as well as among the locations, for these characters. The differences among the environments were significant for plant height, number of pods per plant, number pf seeds per plant, 100-seed weight, days to maturity and number of primary branches per plant. It indicated that material has been studied under variable environments. Similar results were obtained by Singh *et al.* (1994), Thiyagarajan and Rajasekaran (1989) and Chakraborty and Borua (1997).

The mean sum of squares due to genotype x environment interaction were highly significant for days to maturity and significant for days to 50 per cent flowering, suggesting the G x E interaction is very prominent for these two traits. These results are in conformity with the findings of Chakraborty *et al.* (1997). For all other traits under study, the mean sum of squares due to genotype x environment interaction were not significant suggesting that the genotypes under study showed stable performance for most of the traits under study, including the seed yield, in all the three locations. Since the varieties showed stable performance for seed yield in all the three locations, farmers have the option to choose the varieties of their own choice, on the basis of other criteria viz., seed colour, size, shininess, market value, taste and quality etc.

5.3 Analysis of variance for stability parameters as per the stability model of Eberhart and Russell (1966)

The Eberhart and Russell's phenotypic stability model (1966) was applied to determine the stability parameters for two characters namely, days to 50 per cent flowering and days to maturity, possessing significant genotype x environment interaction.

The variance due to environment (linear) were highly significant for both the characters which indicated significant differences among the locations. It is further confirmed as these three locations under the present investigation belong to two different agro-climatic regions. The variance due to genotype x environment (linear) was highly significant for days to maturity, and was found non-significant for days to 50 per cent flowering. Significance of genotype x environment (linear) effect indicated the possibility of predicting these phenological traits over environments and it also suggested that the regression values of different varieties are significantly different from each other, i.e. the extent to which the performance of a variety changes with the environment is quite obvious. These results are in conformity with the findings of Chakraborty *et al.* (1997).

The pooled deviations were found highly significant for days to 50 per cent flowering and were non-significant for days to maturity. Significant pooled deviations in case of days to 50 per cent flowering showed that variation in flowering time was due to some unpredictable factors.

5.4 Estimation of stability parameters

The stability parameters i.e. mean, regression coefficient and deviation form regression are needed to be estimated for determining the stability of traits, over locations. For determining the regression coefficient, the environmental index is to be computed. At Indore, the environmental indices were found to be positive for both the characters i.e., days to 50 per cent flowering and days to maturity. At Dhar, the value of environmental index was positive for days to maturity but negative for days to 50 per cent flowering. At Jhabua, the traits viz., days to 50 per cent flowering and days to maturity exhibited negative values for the same.

The positive values of environmental index suggested that the environment is favourable for the expression of that trait however, the negative indices indicated a negative role of the environment in the expression of that trait. An overall observation of the environmental index for each location suggested that Indore location could be regarded as the most favourable one as it is showing positive values of environmental index for both the traits.

The stability parameters viz., mean, regression coefficient and deviation from regression were computed as per the phenotypic stability model suggested by Eberhart and Russell (1966). According to this model, "a variety with high mean, unit regression coefficient and the deviation from linear regression not significantly different from zero, is said to be the stable one." The stability parameters for both the characters have been discussed character wise here under.

5.4.1 Days to 50 per cent flowering

Genotypes IU31-7 and JU-3 were considered to be the most stable as they had regression coefficient near to unity with low deviation from regression and were delayed to flowering. Genotype TPU-4 with regression coefficient more than unity, showed below average stability and also delayed to flowering.so, it was not desirable.

Variety Type-9 exhibited above average stability and was found to be associated with late flowering. It is found to be well adapted to all the environments. Varieties IU-83-2, IU-88-10 and IU-84-9 showed above average stability and were specifically adapted to poor environments.

Varieties IU 83-2, IU 88-10 and IU 84-9 showed above average stability and were specifically adapted to poor environments.

Varieties IU 8-6, IU 83-4 and JU-2 possessed below average stability and were found to be better under specific environment with early flowering.

5.4.2 Days to maturity

Genotypes JU-2, IU 88-10 and IU 84-9 were considered to be the most desirable as they exhibited above average stability along with low values of deviation from regression and were associated with some what earlier maturity.

Varieties IU 8-6 and IU 83-4 possessed below average stability and were associated with early maturity. These varieties were found to be better under specific environment.

The group of three genotypes, TPU-4, Type-9 and JU-3 exhibited above average stability but these were found to be associated with late maturity and were adapted to all the environments.

Genotypes IU 83-2 and IU 31-7 were highly unstable as they possessed high regression coefficient and also exhibited slightly later maturity of 2-3 days, than the other medium maturating varieties.

The aforesaid results of stability parameters could be summarised as below:

SN	Character	Varieties for low yielding environment	Varieties for specific environment	Stable varieties
1	Days to 50% flowering	IU 83-2, IU 88-10, IU 84-9	IU 8-6, IU 83-4, JU-2	IU 31-7, JU-3, Type-9
2	Days to maturity	JU-2, IU 88-10, JU 84-9	IU 8-6, IU 83-4	TPU-4, Type-9, JU-3

5.5 Stability of traits

The traits namely number of primary branches per plant, number of secondary branches per plant, number of pods per plant, number of seed per pod, 100-seed weight (g) and seed yield per plant (g) showed the least variation over locations (on the basis of mean performance), along with low values of G x E interaction over these locations. Hence, these attributes were found stable over these locations viz., Indore, Dhar and Jhabua.

On the basis of *per se* performance at Indore, the early maturing varieties were IU 8-6, IU 88-10 and IU 84-9. Variety IU 83-2 possessed the highest number of pods per plant followed by JU-2 and IU 31-7. For seed yield per plant variety IU 83-2 showed superior performance followed by JU-2 and Type-9. At Dhar, the early maturing varieties were IU 8-6, IU-2 and IU 83-4. On the basis of number of pods per plant variety IU 83-2 showed superior performance than others followed by Type-9 and IU 31-7. The highest yielding varieties on the basis of seed yield per plant were IU 83-2, Type-9 and JU-2.

At Jhabua, on the basis of per se performance, varieties IU 83-4, IU 8-6 and JU-2 showed early maturity as compared to other genotypes. For number of pods per plant, superior genotypes were IU 83-4, Type-9 and

IU 8-6. For seed yield per plant variety Type-9 showed superior performance followed by IU 83-2 and IU 8-6.

CHAPTER - VI

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FURTHER STUDY

CHAPTER – VI

SUMMARY, CONCLUSIONS AND SUGGESTIONS FOR FURTHER WORK

Summary

Varietal adoptability to various environmental conditions is very important in blackgram genotypes, because they are expected to be grown over a wide range of agro-ecosystems and depends on socio-economic status of the farmers. Thus, identification of stable blackgram genotypes is important to increase the productivity. The present investigation entitled "Adaptation analysis for yield and its attributes in blackgram (*Vigna mungo*)" was carried out with ten blackgram genotypes which were grown in Randomized Block Design with three replications at three locations viz., Indore, Dhar and Jhabua, belonging to different agro-climatic regions.

Observations were recorded on twelve characters viz., days to 50 per cent flowering, days to maturity, plant height (cm), number of primary branches per plant, number of secondary branches per plant, number of pods per plant, number of seeds per plant, number of seeds per pod, 100-seed weight (g), seed yield per plant (g), biological yield per plant (g) and harvest index to study the genotype x environment interaction over locations, to determine adaptability of genotypes for yield and its attributes over locations and to find out the stability of traits over varying environmental conditions using phenotypic stability model suggested by Eberhart and Russell (1966).

The analysis of variance carried out for all the characters in each environment separately, revealed that the variance due to genotypes were highly significant for days to 50 per cent flowering, days to maturity, plant height, number of primary branches per plant and 100-seed weight, at Indore. At Dhar, it were highly significant for days to 50 per cent flowering, days to maturity, number of seeds per pod and number of secondary branches per plant. At Jhabua, the variance due to varieties were highly significant for almost all the characters. The study indicated the presence of marked genetic variability among the experimental material.

The pooled analysis of variance was done for all the characters after applying the Bartlett's test of homogeneity which showed the significant environment differences for plant height, number of pods per plant, number of seeds per plant, 100-seed weight, days to maturity and number of primary branches per plant. It indicated that material has been studied under variable environments. The differences among the genotypes in pooled data were significant for days to 50 per pent flowering, days to maturity, plant height, number of primary branches per plant and, number of seeds per pod. the genotype x environment interaction was found to be significant for days to 50 per pent flowering and days to maturity. Therefore the analysis of variance for stability parameters was done for these two characters only.

The environment (linear) effect was significant for both the characters. The variance due to genotype x environment (linear) was highly significant for days to maturity. The pooled deviations were found highly significant for days to 50 per cent flowering.

The stability parameters i.e. mean, regression coefficient and deviation from regression were estimated for determining the stability of traits, over locations. At Indore, the environmental indices were found to be positive for both the characters. At Dhar the value of environmental index was positive for days to maturity, while at Jhabua, both the traits exhibited negative values of environmental index. An overall observation of the environmental index for each location suggested that Indore location could be regarded as the most favourable one for the expression of both these traits.

The results of stability parameters revealed that under low yielding environment (Jhabua), varieties IU 83-2, IU 88-10 and IU 84-9 proved desirable and stable for days to 50 per cent flowering and varieties JU-2, IU 88-10 and IU 84-9 were found to be desirable and stable for days to maturity.

Under specific environment, varieties IU 8-6 and IU 83-4 were found to be desirable for both the characters i.e. days to 50 per pent flowering and days to maturity.

Varieties IU 31-7, JU-3 and Type-9 proved most suitable and stable for days to 50 per cent flowering and varieties TPU-4, Type-9 and JU-3 for days to maturity. These varieties therefore could prove stable under any of the three locations for these traits.

On the basis of per se performance, the traits namely, number of primary branches per plant, number of secondary branches per plant, number of pods per plant, number of seeds per pod, 100-grain weight and seed yield per plant were found to be the most stable attributes over varying environmental conditions.

Conclusions

Since, in the present investigation the genotype environment interaction was found significant for two developmental traits i.e. days to 50 per cent flowering and days to maturity, the differential role of environment in the expression of these traits could be concluded. However, since the varieties had stable performance over locations for the rest of the traits including yield it gives an opportunity to the farmers to choose the varieties of their preference based on seed colour, seed size, shininess, market value, taste, quality etc.

Varieties IU 88-10 and IU 84-9 were found suitable for poor environment (Jhabua) and IU 8-6 and IU 83-4 performed well under high yielding environment (Indore), but varieties JU-3 and Type-9 were found most suitable and desirable under a range of environments. On the basis of per se performance of the varieties, it could be concluded that variety IU 83-2 showed superior performance under Indore and Dhar conditions and Type-9 was suitable at Indore. The traits namely number of primary branches per plant, number of secondary branches per plant, number of pods per plant, number of seeds per pod, 100-seed weight (g) and seed yield per plant (g) are the most stable traits over varying environmental conditions.

Suggestions for further work

1. More number of recently released genotypes of state and national level should be included for further study.
2. Adaptation analysis could be conducted over more number of locations and it would be more appropriate if at least one location from each agro climatic zone of Madhya Pradesh is included for further study.
3. The experiment should be conducted over years to get the confirmative results and to draw more valid conclusions.

BIBLIOGRAPHY

BIBLIOGRAPHY

Chakraborty, S. and Borua, P.K. (1997). "Stability for seed yield in black gram." *Adv.Pt.Sci*, 10:2,185-188.

Chakraborty, S.; Borua, P.K. and Chakraborty, S. (1997). "Phenotypic stability for phenological traits in black gram (*Vigna mungo* L.Hepper)." *Legume Res.*, 20:3-4,195-188.

Comstock, R.E. and Moll, R.H. (1963). "Genotype x environment interactions." Statistical Genetics and Plant Breeding. *NAS-NRC*, pp.164-196.

Eberhart, S.A. and Russell, W.L. (1966). "Stability parameters for comparing varieties." *Crop Sci.*, 6:26-40.

Finlay, K.W. and Wilkinson, G.N. (1963). "Analysis of adaptation in plant breeding programme." *Aust.J.agric.Res*.14:742-754.

Johannsen, W.L. (1903)." Ueber Erblichkeit in populationen und in reinen Leinen." Gustav Fischer, Jena.

Kalpande, H.V.; Patil, J.G. and Deshmukh R.B. (1996). "Stability analysis for seed yield and its components in green gram." *J.Soils and Crops*, 6:2,173-176.

Mandal, A.B. and Pal, D. (1995). "Performance of different varieties of black gram (*Vigna mungo*) at rainfed conditions in red and laterite soil environment of West Bengal." *Env. Ecol.*, 13:2,457-459.

Manivannan, N. (1999). "Genotype x environment interaction in black gram (*Phaseolus mungo*)." *Indian J.agric.Sci.*, 69:8,598-599

Manivannan, N.; Ramasamy, A. and Nadarajan, N. (1998). "Phenotypic stability analysis in green gram (*Phaseolus radiatus*)." *Indian J.agric.Sci.*, 68:1,31-32.

Mannivannan, N.; Sethuraman, K. and Natrajan, S. (2002). "Studies on stability for seed yield in urdbean". *Legume Res.*, 25(2): 147-148.

Mather, K. and Jinks, J.L. (1971). "Biometrical genetics." Chapman and Hall Ltd., London.

Mishra, R.C. (1990). "Genotype environment interaction and stability analysis in black gram." *Madras Agric.J.*, 77:9-12,513-533.

Muduli, K.C. and Hati, N. (1994). "Stability analysis for seed yield in green gram (*Phaseolus radiatus*) and black gram (*P. mungo*)." *Indian J.agric.Sci.*, 64:3,176-178.

Naidu, N.V.; Satyanarayana, A. and Rajeshwari, V.R. (1993). "Stability analysis for seed yield and shoot nitrogen in greengram (*Phaseolus radiatus*)". *Indian J.agric.Sci.*, 63:2,100-102.

Panse, V.G. and Sukhatme, P.V. (1967). "Statistical methods for agricultural workers." ICAR Publication, New Delhi.

Patil, F.B. and Sonawane, M.N. (1992). "Stability analysis in forage cowpea." *J.Maharashtra agric.Univ.*, 17:1,155-156.

Patil, H.S. and Narkhede, B.N. (1989). "Phenotypic stability of yield, seeds/pod and 100 seed weight in black gram (*Vigna mungo* L.Hepper)." *Legume Res.*, 12:4,189-192.

Patil, H.S. and Narkhede, B.N. (1989). "Stability analysis for pod length and seeds/pod in green gram." *J.Maharashtra agric.Univ.*, 14:2,146-148.

Patil, H.S. and Narkhede, B.N. (1995). "Stability analysis for 100-seed weight, pod/plant and seed yield in green gram (*Vigna radiata* L. Wilczek)." *Legume Res.*, 18:1, 41-44.

Perkins, J.M. and Jinks, J.L. (1968). "Environmental and genotype environmental components of variability." *Heredity*, 23:339-356.

Reddy, P.N.; Kumar, M.H. and Setty, B.V.K. (1990). "Stability analysis of yield and component characters and correlation of stability parameters in green gram (*Phaseolus radiatus*)." *Indian J.agric.Sci.*, 60:11,755-757.

Sharma, R.N.; Borthakur, A.K. and Sharma, S.K. (1993). "Stability analysis in summer sown green gram (*Phaseolus radiatus*)." *Indian J.agric.Sci.*, 63:9,595-596.

Singh, B. and Nanda, P. (1997). "Stability analysis for seed yield in green gram (*Vigna radiate* L.Wilczek)." *Env.Ecol.*, 15:3,595-597.

Singh, B.; Patra, G.J. and Samalo, B.N. (1994). "Genotype x environment interaction in black gram (*Phaseolus mungo*)." *Indian J.agric.Sci.*, 64:12,870-871.

Singh, N.; Yadava, H.S.; Dhakarey, R.P.S. and Singh, N. (1994). "Stability analysis for physiological parameters and seed yield in black gram." Indian *J.Pt.Physiol.*, 37:4,209-213.

Sreekantaradhya, R.; Shivashankar, G.; Kumar, G.S.P.; Virupakshappa, K. and Pradeep Kumar, G.S. (1978). "Yield potential of black gram (*Phaseolus mungo* L.) genotype in Karnataka." *Mysore J.agric.Sci.*, 12:4,542-545.

Thiyagarajan, K. and Rajasekaran, S. (1989). "Stability analysis for seed yield and its components in cowpea [*Vigna unguiculata* (L.) Walp.]." *Legume Res.*, 12:2, 53-60.

Wanjari, K.B.; Khadilkar, B.T. and Deshmukh, N.Y. (1981). "Yield and stability analysis in black gram." *P.K.V.Res.J.*, 5:1, 27-30.

Yadav, I.S. and Kumar, D. (1983). "Association between stability parameters of productive traits in black gram." *Madras agric.J.*, 70:5, 331-333.

Yadav, I.S. and Kumar, D. (1983). "Stability for seed boldness in black gram." *Madras agric.J.*, 70:3,193-194.

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