

**STUDIES ON SEED DEVELOPMENT, MATURATION,
STORABILITY AND SEED QUALITY IN SOYBEAN**
[Glycine max (L.) Merrill] SEED

H. A. SURESHA

DEPARTMENT OF SEED TECHNOLOGY
UNIVERSITY OF AGRICULTURAL SCIENCES
BANGALORE

1991

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**STUDIES ON SEED DEVELOPMENT, MATURATION,
STORABILITY AND SEED QUALITY IN SOYBEAN**
[Glycine max (L.) Merrill] **SEED**

H. A. SURESHA

Thesis submitted to the
University of Agricultural Sciences, Bangalore
in partial fulfilment of the requirements
for the award of the degree of

Master of Science (Agriculture)

IN
SEED TECHNOLOGY

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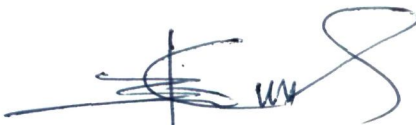
Affectionately Dedicated to
My Beloved Parents
Smt. Parvathamma
and
Sri H. Anjinappa

DEPARTMENT OF SEED TECHNOLOGY
UNIVERSITY OF AGRICULTURAL SCIENCES
BANGALORE

CERTIFICATE

This is to certify that the thesis entitled "STUDIES ON SEED DEVELOPMENT, MATURATION, STORABILITY AND SEED QUALITY IN SOYBEAN (Glycine max (L.) Merrill) SEED" submitted by Mr. H.A. SURESHA, for the degree of MASTER OF SCIENCE (AGRICULTURE) in SEED TECHNOLOGY to the University of Agricultural Sciences, Bangalore, is a record of research work done by him, during the period of his study in this University under my guidance and supervision and the thesis has not been previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

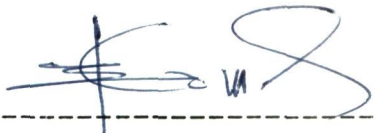
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INTRODUCTION

I INTRODUCTION

Soybean (Glycine max (L.) Merrill) is commonly known as the 'miracle crop' or 'gold from the soil'. It is a rich source of both proteins (40 per cent) and fat (20 per cent). It has excellent nutritional value and possesses some of the essential vitamins like A, B and D.

Soybean is a versatile crop having both food as well as industrial values. Hence it possesses the capacity to revolutionize the agricultural economy, as it has done in United States of America. Being a rich source of high quality protein and oil, it has to be considered as a food crop rather than an oil seed crop or a pulse crop. In view of the chronic shortage of protein and oil in our vegetarian diet, soybean will provide the much needed stability and boost to the production of these most essential items of food.

In Karnataka new soybean varieties from the USA were introduced during 1969-70 and subsequently new varieties have been developed. Since then the crop is becoming popular. The breeder, foundation and certified seed production is being organised and the demand for the quality seeds is increasing.

It is presently grown in most part of the world. This crop is grown on an area of 54.6 million ha with a production of 92.3 million tonnes in the world. In India it is cultivated over an area of 16.54 lakh ha with a production of 14.93 lakh tonnes (Anon., 1990). In Karnataka its area is accounted for about 18,475 ha with an annual production of 16,942 tonnes.

Universally it is felt that seed is one of the important inputs to obtain higher productivity. Such being the case the determination of right stage of maturity for harvesting any crop is important since the quality of the produce is greatly affected by the stage of maturity. The optimal stage of harvesting varies with the crop and varieties and also the purpose for which it is to be used. For determining the stage of harvesting green pods, it is essential and obvious to know much about the changes in some of the physiological characters which do occur during growth and development of the crop.

It is a fact that seed develops from matured fertilized ovule. This ovule development is influenced by the environment and variety. Various kinds of changes take place within the ovule and hence place within the ovule and hence seed maturation is defined as the sum total of all morphological, physico-chemical and physiological changes which occur in the ovule from the stage of fertilization to

harvest. The in depth studies on seed maturation of different varieties of various tropical crops are lacking.

Studies on physiological maturation of seed helps to know when the embryo becomes germinable which is of importance to plant breeders and seed technologists who can harvest early and save important seed material from various kinds of probable hazards. These studies also provide information on dormancy due to biochemical changes in the seed. The maturity studies also provide information regarding, when the seed attains maximum dry matter for physiological maturity and higher vigour and the time gap between physiological maturity and harvest time. These facts are useful for protecting the seed against deterioration. The knowledge of seed maturation helps the seed producer to decide the time of harvest for the maintenance of quality in seeds and to plan post-harvest operations like drying, processing and further storage etc.

The determination of right stage of harvesting is very important since it helps to minimise the seed loss by shattering, to protect the exposure of seeds to field weathering condition and to maintain high seed quality.

One of the biggest impediments in soybean cultivation and production is the rapid loss in seed viability during storage. The farmer is concerned with the phenomenon of

seed longevity because he wants high germination and vigorous seedlings to emerge from the seeds he plants. The seedsman also is concerned with the longevity of seeds, because if germination drops below a certain minimum, his seeds are unsalable and he suffers financial loss. The seed testing association must be concerned with seed ageing (senescence) because he must minimize the ageing which occurs between sampling and testing in order to get a true measure of the quality of the lot being tested. Besides all the mankind should be concerned with seed longevity which is essential to our survival in the changing ecology of this world.

Seed storage requirements range in complexity from those of a farmer saving his seed to plant a few months later, still longer storage period for carry over seeds in seed stores and still long storage periods for breeding material in plant gene banks. The storage problem increased in complexity depending upon the severity of ambient climate and length of storage period.

Available information on these aspects is very scanty. So the present investigation entitled "Studies on Seed Development, Maturation, Storability and Seed Quality in Soybean (Glycine max (L.) Merrill) was undertaken at the National Seed Project, 'J' block, Gandhi Krishi Vignana

Kendra, Bangalore, during 1990-91 with the following objectives:

1. To fix the stage of physiological maturity and harvest maturity in different varieties of soybean,
2. To assess the extent of field shattering of seeds in different varieties of soybean,
3. To assess the quality of seeds at various stages of harvesting in storage and
4. To fix up the optimum and stage which gives the least shattering loss with the highest seed quality.

REVIEW OF LITERATURE

II REVIEW OF LITERATURE

In this chapter, the literature available pertaining to the seed development, maturation, storability and seed quality in seeds of soybean has been reviewed.

2.1 Physiological maturity of seeds in relation to pod and seed development

The determination of right stage of maturity for harvesting any crop is important. The quality of the seed is entirely dependent on the stage of maturity. The desirable stage of harvesting varies not only with the crop but also with the varieties and the purpose for which it is used. When the crop is grown mainly for seed purpose, the right stage of harvesting the crop is very important as any delay or early harvest result in poor seed quality.

Harrington (1972) defined physiological maturity as that stage when the seed had attained maximum dry weight.

Burris (1973) studied four soybean cultivars and reported that the size increased linearly with increase in time after flowering. Germination percentage increased with increase in time after flowering although some cultivars showed a reduction in germination (between 30 and 40 days) due to increased percentage of hard seeds.

Jacinto ^{and Carlos Filho} et al. (1974) sampled the soybean seeds after flowering at 8 days interval and studied for moisture content, size, dry weight, germination capacity and seedling vigour. When moisture content was relatively high (58%), the germination was low (65%). High germination (98.4%) was obtained eight days before harvest.

Crookston and Hill (1979) reported that the complete loss of green colour from the pods and seed shrinkage as the reliable indicators of physiological maturity.

Dharmasen and Jackobs (1979) reported that delayed harvesting of soybean seeds caused deterioration.

Tekrony et al. (1979) reported that the time interval from physiological maturity to harvest maturity ranged from 9 to 24 days among six cultivars. Harvest maturity and full maturity (when 95% of pods reached their maturity colour) occurred almost simultaneously in early cultivars, but 5 to 8 days apart in the late cultivars.

Marcosfilho (1980) observed that the absence of yellowish green seeds with loss of green colour from the pods were useful and acceptable indicators of physiological maturity in addition to maximum dry weight of seeds in soybean.

Obendorf et al. (1980) studied the growth, maturation and germination of soybean cultivar Chippawa-64 under green-house and field conditions. Flowers were tagged on main stem and pods were harvested at four days interval between 22 and 58 days after flowering. Mean daily growth rates were 7.8 and 4.9 mg per seed in green house and field grown seeds, respectively. At 50 days after flowering air dried matured seed had higher capacity for germination between 34 and 46 days after flowering.

The seeds of soybean cultivars dried after shelling were non-viable as compared to seeds dried without shelling (Reicosky, 1980).

Gbiki and Crookston (1981) reported that loss of green pod colour was the most reliable indicator of physiological maturity.

Tekrony et al. (1981) made an attempt to relate visual indicators of soybean pod development to physiological maturity and stated that the attainment of a single normal pod on the main stem to its mature colour was more accurate and reliable indicator of physiological maturity.

Beaver and Cooper (1982) reported that in two indeterminate soybean cultivars, Corsoy reached maturity two weeks earlier than Williams, but had the same seed filling period. Corsoy accumulated reproductive (seed and pod wall) dry

Weight at a greater rate than Williams

Yoshida et al. (1983) studied that the determinate cultivar seed from the last flowering group had slow dry matter accumulation and a short effective seed filling period, where as in indeterminate cultivars, seeds from the last flowers had a short seed filling period.

2.2. Physiological maturity of seeds in relation to dry matter accumulation.

Jacintho and Carvalho et al.(1974) studied the seed maturation of soybean cultivar Vicoja at an interval of 8 days upto 104 days after flowering and observed that the seeds attained the maximum dry weight on 72 days after flowering.

Egli (1975) studied the rate of accumulation of dry weight of soybean seeds. He observed the daily rate of seed dry matter accumulation ranging from 3.38 to 8.32 mg. per seed in cultivar Amsoy, Custer and York. Significant differences were observed among the cultivars in the accumulation of dry matter.

Crookston and Hill (1979) also studied the physiological maturity of soybean seeds and found maximum dry weight when seeds have an average of 58 per cent moisture content.

Gbikpi and Crookston (1980) observed that the dry matter accumulation was consistently faster in late maturing soybean cultivars.

Marcosfilho (1980) studied that the maximum soybean seed dry weight was found to be insufficient by itself to characteristic physiological maturity.

Obendorf et al. (1980) reported that soybean seeds attained maximum dry weight on 50th day after flowering.

Tekronyet al. (1981) opined that physiological maturity represented an important growth stage of crop plants since it is normally associated with the maximum accumulation of dry seed weight and further indicated that the seeds of soybean attained maturity when the seeds or pods turned completely yellow.

Tymchuk (1981) reported that rate of accumulation of dry matter in seeds of soybean was a varietal characteristic.

Egli et al. (1982) reported that the length and width of the soybean pods reached the maximum before the moisture content of the seed declined steadily as the seed approached its maximum dry weight.

Hu ge et al. (1982) reported that all the five cultivars of soybean tested differed significantly in total dry

matter accumulation and it was the most rapid in Monetta.

Yoshida et al. (1983) reported that seed dry matter change followed a sigmoid curve and was faster in large seeded than small seeded.

Kalavathi and Ramaswamy (1988) suggested that soybean seeds collected on the 55th day were superior to those collected on 40, 45, 50 or 60 days after 50 per cent flowering in dry matter accumulation.

2.3 Physiological maturity in relation to germination

Green and Pinnell et al. (1965) observed that cultivar Horosov sown early and matured before the onset of dry weather and recorded lower seed germination percentage compared to late sown crop with maturity in hot dry weather.

Burris (1973) reported that root and shoot length of soybean seeds after germination increased with the increase in time after harvest.

Jacinto and Carvalho et al. (1974) sampled the soybean seeds after flowering at 8 days interval and studied for moisture content, highest germination (93.4%) was obtained in seeds harvested eight days before the harvest.

Obendorf et al. (1978) observed that a minimum of 40 mg seed weight was required for 80 to 90 per cent germination.

Amble (1980) reported that the seeds of three cultivars of soybean viz., Davis CES 407 and F 62-3977 recorded the highest germination percentage when harvested at 90, 121 and 123 days, respectively after sowing.

Obendorf et al. (1980) reported that germination per cent was maximum in seeds harvested 50th day after flowering.

Tekrony et al. (1981) opined that the viability and vigour of soybean seeds were the highest only at the time of physiological maturity.

Gbipki and Crookston. (1981) reported that disappearance of green colour of all the pods was found to be the most reliable indicator of physiological maturity.

Park (1981) found that germination of dried soybean seeds after removal from the pod was inhibited significantly in the early seed filling stages.

Singh and Gupta (1982) reported that germination potential and seedling vigour were maximum in seeds harvested at physiological maturity which was attained 100 days after sowing.

Prokobboon and Noglör (1987) reported that the highest germination per cent was obtained with harvesting 55 days

after 50 per cent flowering with a corresponding moisture content of 31.4 per cent. Further he stated that the earlier harvesting (40 to 50 days after 50 per cent flowering) markedly reduced germination.

Kalavathi and Ramaswamy (1988) found that soybean seeds collected on the 55th day after 50 per cent flowering were superior to those collected on 40, 45, 50 or 60 days after 50 per cent flowering in germination.

Miles et al. (1988) concluded that freshly harvested immature soybean seeds did not need a desiccation period prior to expression of maximum viability and normal seedling development. However, maximum germination did not occur until maximum accumulation of dry seed weight.

2.4 Physiological maturity of seeds in relation to moisture content

Tsuchiya and Sunanda (1977) reported that the maturity of soybean seeds was associated with the decrease in the moisture content of the pods.

^{and Hill}
Crookston et al. (1979) reported that the maximum dry weight of soybean seeds occurred when the moisture content is above 58 per cent.

Tekrony et al. (1979) reported that the physiological maturity in soybean occurred when the seed moisture content was 50 to 60 per cent i.e., 2 to 3 weeks before commercial harvest.

Obendorf et al. (1980) reported that maximum seed dry weight of soybean seeds occurred when the seed moisture content was 59 and 61 per cent, respectively at 50 days after flowering.

Tekrony et al. (1980) reported that the physiological maturity in soybean occurred when the seed moisture content was approximately 55 per cent and the time interval, from physiological maturity to harvest maturity ranged from 10 to 20 days.

Gbikpi and Crookston (1981) reported that the early maturing seeds reached physiological maturity 11 days before late maturing soybean seeds, when the moisture content was 44 per cent.

Yaklich (1981) reported that the largest single day increase in moisture content was 13.8 and 15.6 per cent for pods and seeds, respectively. The largest single day decrease in moisture content was 16.8 and 7.0 per cent for pods and seeds, respectively. This showed that pod and seed moisture changed daily and indicated that this moisture change may be the cause of seed deterioration.

2.5 Harvesting maturity of seeds in relation to seed quality

Lampang (1972) reported that the seeds harvested when the lower leaves had fallen recorded the same germinability as that of seeds harvested after full maturity.

Dhingra et al. (1978) studied the effect of delayed harvesting by 7, 14, 21 and 28 days from maturity. Harvesting 14 days after maturity had significantly higher percentage of seed infection of Phomopsis sojæ, Fusarium spp.

Costa (1979) reported that the seed quality and seedling emergence decreased with delayed harvesting. Alternating periods of rainfall and high temperature enhanced seed deterioration and rainfall during harvesting decreased the seedling emergence.

Tekrony et al. (1979) studied the time interval from physiological maturity to harvesting maturity.

Matsumoto (1980) reported that germination percentage of soybean increased with delayed harvesting. †

Servero et al. (1981) found that the maximum seed vigour occurred at physiological maturity and vigour decreased progressively with delayed harvest. Occurrence of

microorganisms increased as the harvest was delayed.

Inove et al. (1982) studied that the optimum harvest date was upto 3 days after maturity, where the moisture content was around 20 to 25 per cent and loss due to pod shattering was less than 5 per cent.

Vieira et al. (1982) found that the delayed harvesting markedly decreased the seed germination and vigour. Seeds with shrunken seed coat increased due to delay harvest.

Carroro et al. (1983) observed that the seed quality was reduced more by rainfall before harvest than by delay in harvesting after maturity.

Carraro and Rosenthan (1983) observed that the delayed harvesting recorded lower seed germination per cent, vigour index and field emergence due to rains before harvest.

Ortiz and Cianzio (1983) reported that seeds harvested 5 to 6 weeks after flowering would gave higher germination and field stand.

Iglesias and Abreau (1984) reported that the optimum seed quality in variety Vavilov 63-A was obtained by harvesting 10 days after 95% of the pods are matured.

Iysesias (1984) studied the germination and emergence of seeds harvested 0, 15, 19, 15 and 20 days after 95 per

cent of the seeds had dried. It was concluded that for optimum quality the seeds could be harvested upto 10 days after drying. The corresponding moisture content was 31.4 per cent. Harvesting before 50 days after 50 per cent flowering significantly reduced the germination.

Kalavathi and Ramaswamy (1988) found that the soybean seeds collected on the 55th day after 50 per cent flowering were superior to those collected 40, 45, 50 and 60 days after 50 per cent flowering in germination percentage, root and shoot length.

Marcosfilho and Carvalho (1988) reported that the delayed harvesting resulted in poor quality of seeds due to adverse weather conditions that prevailed in the later stage of crop growth.

Adam and McDonald (1989) reported that the late harvesting decreased the germination per cent, seedling growth rate and accelerated ageing germination whereas, electrical conductivity of seed increased.

Reis and Rocha (1989) found that the delayed harvesting decreased the seed viability and vigour. Seed yield was drastically reduced due to increased field losses.

2.6 Optimum stage of harvesting in relation to seed shattering

Quick (1974) reported that among different methods for testing shattering index for soybean, the pods suture method compression method was found to be the simplest and accurate.

Hogg (1975) found that the measurement of physical properties like impact force requirement for predicted shatter loss was compared with observed values for cultivar Amsoy 71 and it helped to determine the optimum harvest date.

Summers and Hanna (1986) reported that the in situ wetting of soybean prior to harvesting was used as a means of reducing the shatter losses.

Tsuchiya (1987) observed that the soybean pod shattering was influenced by the presence of fibrous tissue in the jointry region, environment, pod moisture content and varietal characteristic. Pod shattering of more than 78% was considered as susceptible to shattering and less than 10 per cent as resistant.

Philbrook and Oplinger (1989) reported that the average soybean field loss was 10 per cent of the potential yield. Field loss of 6.1 per cent at harvest maturity increased to

13.9 per cent at 42 days after maturity. Delayed harvesting led to reduction in net yield of 11 kg/ha/day.

2.7 Storability studies

Tedia (1977) studied the loss of storage with 7 to 10 per cent moisture content of seeds.

Matsumoto (1978) reported that the soybean seeds with higher germination had better storability as compared to seeds with lower initial germination percentage.

Coelho et al. (1979) observed that the soybean seeds could be stored safely at 28°C and 66 per cent relative humidity and with this combination the seed deterioration was the least.

Amark et al. (1983) studied the effect of jute, polythene and multilayered paper bags. There was no initial difference between the containers but after 5 months of open storage seeds showed reduced germination and vigour. *Soybean*.

^vLatcher and Godon (1984) reported that the seeds stored in plastic bags maintained 90 per cent germination even after 12 months of storage.

Moreira and Chaves (1984-85) reported that the apparent specific gravity values determined using different liquids like toluene and soybean oil (both the liquids) did not

differ insignificantly.

Stipichitt et al. (1989) studied that the delayed harvesting recorded lower seed germination per cent, vigour index and field emergence due to rains before harvest.

MATERIAL AND METHODS

III MATERIAL AND METHODS

The present study was conducted with five different varieties of soybean to study the course of seed development, maturation, storability and quality. The materials used and techniques adopted during the course of this investigation are described in this chapter.

3.1 General description

3.1.1 Location

The study was conducted at the National Seed Project 'J' Block, University of Agricultural Sciences, G.K.V.K., Bangalore from September to December, 1990 and January to August, 1991.

3.2 Meteorological data during crop growth period

The weather data prevailed during crop growth period of rabi 1990 is presented in Table 3.1 and depicted in Figure 3.1.

During rabi 1990 (crop growth period) the rainfall was less than the normal in August, September, October, November and December (79.7, 92.6, 111.9, 32.2 and 4.8 mm, respectively). In general minimum temperatures were less than the normal ranging from 26.1°C to 28.1°C. Maximum temperatures

Table 3.1: Normal and actual monthly weather data prevailed during the crop growth period of rabi 1990 at Gandhi Krishi Vignana Kendra, NSP 'J' Block, Bangalore.

Month	Total rainfall(mm)		Temperature °C				Relative humidity (%)				Daily sunshine hours				
	N	A	D	N	A	D	Maximum	Minimum	N	A	D	N	A	D	
August	117.9	79.7	-38.2	28.0	26.5	-1.5	18.7	17.2	-1.5	73	75	2	5.1	3.9	-1.2
September	331.6	93.6	-127.0	28.2	28.1	-0.1	18.5	19.4	0.9	73	68	-5	6.0	5.6	-0.4
October	164.2	119.9	-52.3	23.8	27.4	-0.4	18.0	20.2	2.2	72	73	1	-6.71	4.9	-1.8
November	39.5	32.2	-7.3	26.8	26.4	-0.4	16.0	17.1	1.7	70	67	-3	6.80	6.1	-0.7
December	14.8	4.8	-10.0	26.2	26.1	-0.1	14.2	14.8	0.6	69	64	-5	7.80	8.5	0.7

N = Normal A = Actual D = Deviation

Normal data are the mean from 1971-1990 at GKVK, Bangalore.

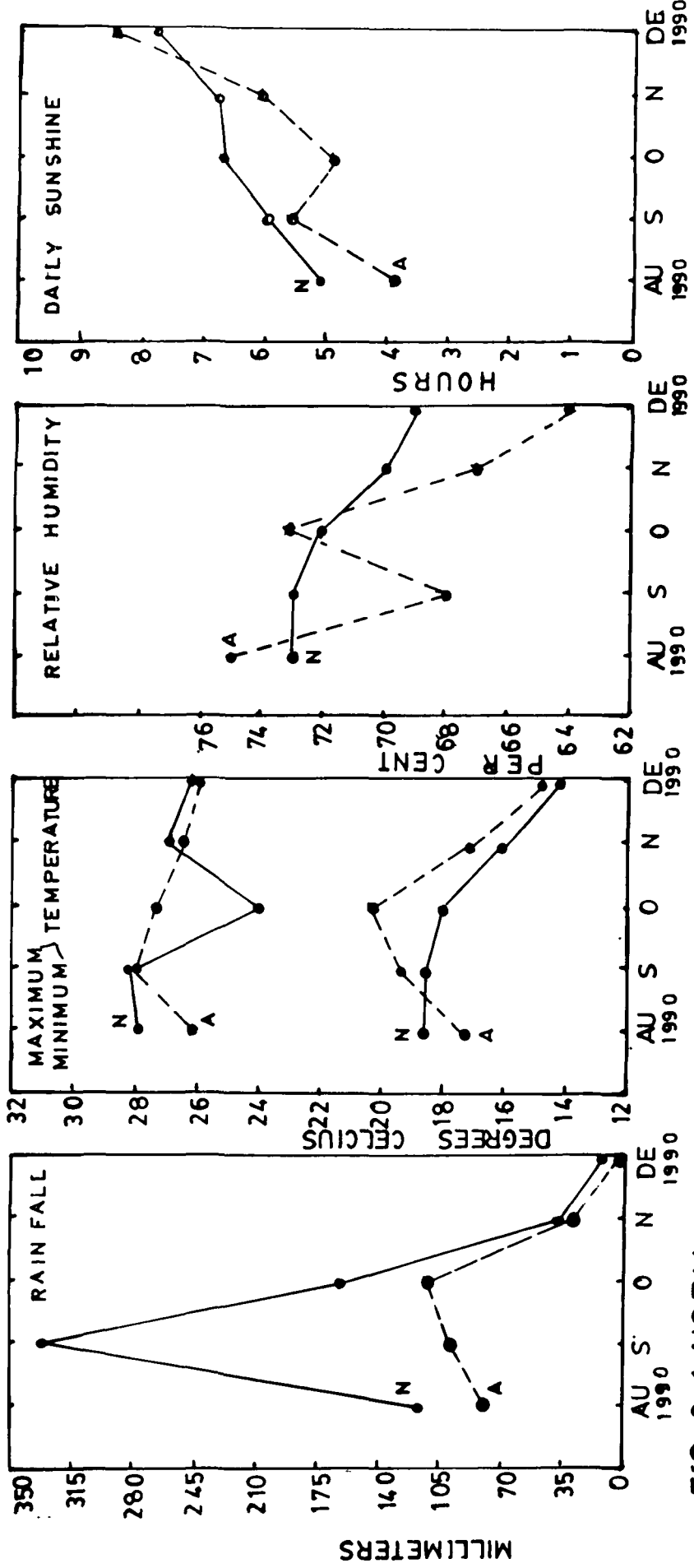


FIG. 3.1. NORMAL AND ACTUAL MONTHLY WEATHER DATA PREVAILED DURING RABI, 1990 AT GKVK, BANGALORE

were more than the normal except in the month of August ranging from 17.1°C to 20.2°C . The normal daily bright sunshine hours were longer during crop growth period in August (5.1 h), September (5.6 h), November (6.8 h), December (8.5 h) and shorter in the month of October (4.9 hours) compared to normals, the actual bright sunshine hours during crop growth period from September to November were shorter.

3.2 Meteorological data during the storage

The weather data on mean, maximum, minimum temperature, relative humidity and rainfall during storage studies are presented in Table 3.2 and also shown in Figure 3.2.

During the storage period (Jan., to Aug., 1990) the rainfall was less than the normal in January, February, March and May (0.4, 8.8, 10.7 and 9.4 mm, respectively) while it was more than the normal in April, June, July and August (60.4, 114.4, 98.5 and 34.4 mm). The maximum and minimum temperatures recorded ranged from 15.4°C to 20.8°C and from 13.4°C to 20.2°C respectively. The actual maximum temperatures were less than the normal. However, the normal and actual minimum temperatures did not decrease much.

The relative humidity was recorded during the storage period by using hygrometer. The normal relative humidity was the highest in the months of July (72%) and August (73%) whereas in March (58%) and April (53%) it was the

Table 3.2: Weather data on temperature ($^{\circ}\text{C}$), relative humidity (%), and rainfall (mm) recorded during storage studies of January to August 1991 at GKVK, Bangalore.

Months	Temperature($^{\circ}\text{C}$)						Relative humidity(%)						Rainfall (mm)													
	Maximum			Minimum			N			A			D			N			A			D				
	N	A	D	N	A	D	N	A	D	N	A	D	N	A	D	N	A	D	N	A	D					
January	28.4	15.4	-13.0	13.4	13.4	0.00	63.0	63.0	0.00	0.00	0.00	1.40	1.00	-0.40	30.1	15.7	-14.4	15.1	15.0	-0.10	55.0	53.0	-2.00	8.80	0.00	-8.80
February	33.2	19.6	-13.6	17.8	17.6	-0.20	50.0	50.0	0.00	0.00	0.00	14.30	3.60	-10.70	33.2	19.6	-13.6	17.8	17.6	-0.20	50.0	50.0	0.00	14.30	3.60	-10.70
March	33.2	20.8	-12.4	20.4	20.2	-0.20	53.0	53.0	2.00	2.00	2.00	27.60	88.00	60.40	33.2	20.8	-12.4	20.4	20.2	-0.20	53.0	55.0	2.00	27.60	88.00	60.40
April	33.5	20.5	-13.0	20.4	20.3	-0.10	58.0	60.0	2.00	2.00	2.00	99.00	89.60	-9.40	33.5	20.5	-13.0	20.4	20.3	-0.10	58.0	60.0	2.00	99.00	89.60	-9.40
May	28.2	19.5	-8.70	19.0	19.0	0.00	68.0	67.0	-1.00	-1.00	-1.00	68.50	212.90	114.40	28.2	19.5	-8.70	19.0	19.0	0.00	68.0	67.0	-1.00	68.50	212.90	114.40
June	28.0	17.9	-10.1	18.0	18.6	0.60	72.0	70.0	-2.00	-2.00	-2.00	111.50	210.10	98.50	28.0	17.9	-10.1	18.0	18.6	0.60	72.0	70.0	-2.00	111.50	210.10	98.50
July	28.0	17.6	-9.40	18.7	18.3	-0.40	73.0	69.0	-4.00	-4.00	-4.00	117.90	152.20	34.30	28.0	17.6	-9.40	18.7	18.3	-0.40	73.0	69.0	-4.00	117.90	152.20	34.30

N = Normal A = Actual D = Deviation
 Normal data are the mean from 1971 to 1989 at G.K.V.K., Bangalore.

lowest. The actual RH was slightly lower than that of normal during February, June, July and August.

3.3 Seed material

Five cultivars of soybean viz., Monetta, PK 471, Bragg, Hardee and KHSb2 were obtained from the National Seed Project, G.K.V.K., Bangalore. The salient features of these cultivars are as follows:

3.3.1 Monetta

It is a variety released by the Central Seed Committee for cultivation in the Central Zone. It is a determinate type with purple coloured flowers. The variety grows upto a height of 41.3 cm. The pods are brown coloured. It takes about 34 to 36 days for 50 per cent flowering. It matures in 70 to 80 days. The 100 seed weight is about 13 to 17 g. The average seed yield is about 16 to 19 q/ha under irrigated condition. It is recommended for all the soybean growing area.

3.3.2 PK 471

Released in 1985 in Uttar Pradesh. It is a determinate type with white coloured flowers. The variety grows to a height of 55.5 cm. The pods are grey and hairy. It takes about 39 days for 50 per cent flowering. It matures in 95

to 100 days. The 100 seed weight is about 16.5 to 17 gm. The average seed yield is about 23.24 q/ha under irrigated condition. It is recommended for all the soybean growing area.

3.3.3. Bragg

It is an introduction from the U.S.A. and released in Uttar Pradesh. It is a determinate type with white coloured flowers. The variety has a height of 56.5 cms. The pods are pale green and hair. It takes about 38 days for 50 per cent flowering. It matures in 95 to 100 days. The 100 seed weight is about 17.5 to 18 gm. The average seed yield is about 24.5 q/ha under irrigated condition. It is recommended for all the soybean growing area.

3.3.4 Hardee

It is an introduction from the USA released in 1976 in Karnataka. It is a determinate type with white flowers. The variety grows to a height of 57.6 cm. The pods are grey, on an average it takes about 42 days for 50 per cent flowering. It matures in 100 to 105 days. The 100 seed weight is about 18.7 gm. The average seed yield is about 25.5 q/ha under irrigated condition. It is recommended for all soybean growing area.

3.3.5. KHSb 2

It is a variety developed by the University of Agricultural Sciences, Bangalore. It is a semi-determinate type with pink coloured flowers. The pods are brown and droopy. It takes about 52 days for 50 per cent flowering. It matures in 115 to 120 days. The 100 seed weight is about 15.7 gm. The average seed yield is about 24.89 q/ha under irrigated condition. It is recommended for all the soybean growing area.

3.4 Experimental details

The following three experiments were conducted

1. Studies on the Course of Pod and Seed Development in Soybean Varieties;
2. Studies on the Effects of Stages of Harvesting in Soybean Varieties and
3. Studies on the Effects of Harvesting Stages on the Storability in Soybean varieties.

3.5 Experiment - I:

Studies on the Course of Pod and Seed Development in Soybean Varieties

Objectives:

To study the course of pod and seed development so as to fix up the stage of physiological maturity in different varieties of soybean.

3.5.1 Details of experiment

Five varieties (v) of soybean viz., Monetta (V1), PK 471 (V2), Bragg (V3), Hardee (V4) and KHSb 2 (V5) were grown in the red sandy loam soils at 'J' Block, G.K.V.K., during rabi 1990 following the recommended package of practices.

3.5.2 Other details

Gross plot size	:	3 m X 2.0 m
Net plot size	:	2.4 m X 2.0 m
Row spacing	:	30 cm X 10 cm

3.5.3 Procedure followed in the physiological maturity studies

About 400 flowers opened on the same day at the time of 50 per cent flowering were randomly selected and tagged during early morning in each variety and in each net plot. The age of pods per seeds of just opened flowers was taken as zero day. Ten developing pods were picked randomly from

the tagged flowers in each plot during each sampling.

Sampling of the 10 pods was made in the beginning at an interval of 5 days and at later stages with 2 days interval. Sampling was made after 15, 20, 25, 30, 35, 40, 42, 44, 46, 48, 50 and 54 days after 50 per cent flowering.

The pods were brought to the laboratory in polythene covers to avoid any moisture loss. After separating the seeds carefully from these pods, the following observations were recorded:

1. Fresh weight of the husk per 10 pods
2. Fresh weight of the seed per 10 pod
3. Dry weight of the husk per 10 pods
4. Dry weight of the seeds per 10 pods
5. Moisture content of the husk
6. Moisture content of the seed.
7. Germination percentage
8. Seedling length
9. Seedling dry weight
10. Vigour index.

3.5.4.1 Fresh weight of husk per pod

The mean fresh weight of husk per 10 pods was determined from the samples after removing the seeds from the pod. The weight of the husks of 10 pods was weighed by

using a Top Pan Precision balance and expressed as g/10 pods.

3.5.4.2 Dry weight of husk per 10 pod

The husk after taking fresh weight was used for determining the dry weight. The husk was dried in a hot air oven at $80^{\circ}\text{C} \pm 1^{\circ}\text{C}$ for 24h. Subsequent cooling was done inside the desiccator. Weight of the dried husks was determined and the dry weight of husk per 10 pods was calculated and expressed in grams.

3.5.4.3 Moisture content of husk per 10 pods

It was determined by low constant temperature oven method (110°C for 1 hour) as per the International Seed Testing Association Rules (Anon., 1985). The known quantity of husk was taken in the non corrosive glass container. The husk of 10 pods was dried in a hot air oven at 80°C for 24 hour. After cooling, weight of the husk was determined and expressed in percentage, using the following equation.

$$\text{MC} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

where,

MC = Moisture content of husk per 10 pods (%)

W1 = Weight of empty container (g)

W2 = Weight of the container + husk per 10 pods before
drying (g)

W3 = Weight of container + husk per pod after drying (g)

3.5.4.4. Fresh weight of seeds per 10 pods

The seeds separated from the sampled pods were weighed and the fresh weight of seeds per 10 pods was determined and expressed in grams.

3.5.4.5 Dry weight of seed per 10 pods

The seeds used for determining of fresh weight were dried in hot air oven at 80°C for 24 h. Subsequently cooling was done in the desiccator. Weight of dried seeds was determined and expressed in grams.

3.5.4.6 Moisture content of seeds

It was determined by high constant temperature method as per I.S.T.A rule (Anon., 1985). A known quantity of seeds was taken in non-corrosive metal dishes. These seeds were dried in hot air oven at $103^{\circ}\text{C} \pm 1^{\circ}\text{C}$ for 1 hour. After cooling, weight of the seeds was determined and expressed in percentage using the following equation:

$$MC = \frac{W2 - W3}{W2 - W1} \times 100$$

where,

MC = Moisture content of seeds (%)

W1 = Weight of empty metal dish (g)

W2 = Weight of dish + seeds before drying (g)

W3 = Weight of dish + seeds after drying (g)

3.5.4.7 Germination percentage

The germination percentage was determined as per the ISTA rules (Anon., 1985) in the Seed Technology Research Laboratory, 'J' Block, G.K.V.K., where the temperature $25^{\circ}\text{C} \pm 1^{\circ}\text{C}$ and 95 per cent relative humidity were maintained. The germination count was taken on the fifth and eight day and expressed in percentage.

3.5.4.3 Seedling length measurements

100 X 4 seeds in each treatment were planted in rolled towels medium and were placed in germinator at 45° angle at $25^{\circ}\text{C} \pm 1^{\circ}\text{C}$. After 8 days period the length of seedlings was measured the average length of seedlings was calculated and expressed in cm.

3.5.4.9 Seedling dry weight

The normal 10 seedlings were selected at random from each sample on eighth day of germination and were transferred to oven at $85^{\circ}\text{C} \pm 2^{\circ}\text{C}$ for 24 hours. Then the seedlings were removed and kept in desiccator for cooling. The weight of the dried seedlings was recorded in mg.

3.5.4.10 Vigour index

Vigour index was calculated using the (Abdul Baki and Anderson, 1973).

1. Vigour index = Product of the mean length of seedling (cm) and germination percentage (%)
2. Vigour index = Product of the germination percentage and mean seedling dry weight (mg)

3.6 Statistical analysis

The data were statistically analysed as per methods outlined by Cochran and Cox (1965) adopting the analysis of variance technique appropriate to the design followed.

3.7 Experiments - II:

Studies on Optimum Harvesting Stages in Soybean Varieties

Objectives:

1. To fix up the optimum stage of harvesting maturity in different varieties of soybean.,
2. To assess the extent of field shattering of seeds in different varieties of soybean and
3. To fix up the optimum stage which gives the least shattering loss with highest seed quality.

3.7.1 Details of experiments

Five varieties (V) of soybean viz., Monetta (V1), PK 471 (V2), Bragg (V3), Hardee (V4) and KHSb2 (V5) were grown in the red sandy loam soils at 'J' block, G.K.V.K., during 1990-91 following the recommended package of practices.

3.7.2 Other details:

Gross plot size : 1.8 m X 1.5 m
Net plot size : 1.2 X 1.5 m
Row spacing : 30 cm x 10 cm

Harvesting stages: (H) : 8 No.

1. Harvesting when at least 25% of pods in each plant attained yellow colour (No shattering of pods)
.....(H1)
2. Harvesting when at least 50% of pods in each plant attained yellow colour (No shattering of pods)
..... (H2)
3. Harvesting when at least 75% of pods in each plant attained yellow colour (No shattering of pods)
..... (H3)
4. Harvesting at dried up stage of pods (at the beginning of shattering)
.....(H4)
5. Harvesting at dried up stage of pods (3 days after first shattering)
..... (H5)
6. Harvesting at dried up stage of pods (6 days after first shattering)
..... (H6)
7. Harvesting at dried up stage of pods (9 days after first shattering)
..... (H7)
8. Harvesting at dried up stage of pods (12 days after first shattering)
..... (H8)

At each harvesting stage, plants were harvested from each plot as soon as the above stages were achieved. Harvested plants were spread in single layer and dried pods were hand threshed by using sticks. Seeds were again dried to bring down moisture content around 9 per cent by such drying. These seeds were subjected to storability studies at seed Technology Research Laboratory, NSP, G.K.V.K., Bangalore.

From the second experiment the following observations were made:

1. Pod shattering
2. Test weight of 100 seeds

Number of pods shattered per plant was recorded at different stages of harvesting so that H4 (harvesting) stage coincided with beginning of shattering, 3 days (H5), 6 days (H6), 9 days (H7) and 12 days (H8) after first shattering. Pod shattering (per cent of pods shattered to the total number of pods per plant) percentage was calculated at each harvesting stage from H4 (beginning of shattering to 12 days (H8) after first shattering.

Test weight of 100 seeds

The test weight of 100 seeds of soybean varieties at different harvesting stages was determined expressed in

grams.

3.8 Experiment - III:

Studies on the Storability at Different Maturity Stages in Soybean Varieties.

Objectives:

To assess the quality of seeds harvested at various stages of maturity and their storability.

The experiment was conducted at Seed Technology Research Laboratory, NSP, 'J' Block, G.K.V.K., Bangalore under ambient conditions. The seeds harvested from experiment-II at different harvesting stages were used for the storability studies.

3.8.1 Details of experiment

Seeds of all the five varieties of soybean viz., Monetta (V1), PK 471 (V2), Bragg (V3), Hardee (V4) and KHSb2 (V5) harvested at eight different stages H1 (25% of pods in yellow colour), H2 (50% of pods in yellow colour), H3 (75% of pods in yellow colour), in H4 (the beginning of shattering), 3 days (H5), 6 days (H6), 9 days (H7) and 12 days (H8) after first shattering seeds were treated with thiram @ 2 g/kg seed and stored in cloth bag for a period of 8 months.

Treatments procedure

The seeds were treated with Thiram @ 2 g/kg of seeds was mixed with the seeds were stored in cloth bag. The weather data viz., temperature, relative humidity and rainfall received during the storage period are presented in Table. 3.2.

From the stored seeds the following observations were made:.

1. Lab germination (%)
2. Vigour index
3. Field emergence (%)
4. Electrical conductivity (micro mhos/cm)

3.8.3 Field emergence test

Field emergence test was conducted at the Field Unit at National Seed Project, 'J' block, University of Agricultural Sciences, G.K.V.K., Bangalore.

The soil was sandy loam. 100X4 seeds in each tretment were sown approximately at 2.5 cm deep in rows. The rows were 30 cm apart and within the row, the seeds were spaced 10 cm apart. The plots were irrigated as and when needed. The first and second count of field emergence were taken after 5 and 8 days of sowing, respectively in all the

varieties and expressed in percentage. The field emergence was conducted at monthly intervals.

3.7.3 Electrical conductivity of seed leachate (E.C)

Five grams of seeds were surface sterilized by using methoxy ethonol to remove the chemicals coated on the seeds surface. Then they were throughly washed with double distilled water for 3 to 4 times. Then those seeds were soaked in 25 ml of double distilled water for 24 hours at room temperature. Then the steep water was decanted and the electrical conductance of leachate was measured in the digital conductivity meter model (Sensitive conductivity Cell-CCS-811). After substracting the E.C of distilled water from the value obtained from the seed leachate, the actual electrical conductivity was measured and expressed in micro mhos/cm at $25^{\circ}\pm 1^{\circ}\text{C}$.

3.9 Statistical analysis

The data were statistically analysed as per the methods outlined by Cochran and Cox (1965) adopting the analysis of variance technique and interpreted at 5 per cent level of significance.

EXPERIMENTAL RESULTS

IV EXPERIMENTAL RESULTS

The results of experiments on (i) The Course of Pod and Seed Development (ii) Effects of Optimum Stages of Harvesting and (iii) Effects of Harvesting Stages and Storability on seed Quality in five varieties of soybean are presented in this chapter.

4.1 Studies on Pod and Seed Development in Soybean Varieties

4.1.1 Number of days taken to 50 per cent flowering and physiological maturity

The data on the number of days taken to 50 per cent flowering and physiological maturity in different soybean varieties sown during rabi 1990 are presented in Table 4.1 and graphically illustrated in Fig 4.1.

The number of days taken to 50 per cent flowering differed significantly among the varieties of soybean. It ranged from 33 to 43 days. Monetta (33 days) flowered significantly earlier than others. PK 471 (37 days) and Bragg (37 days) were medium. Hardee (40 days) and KHSb2 (43 days) took significantly more number of days for 50 per cent flowering than others. Even in physiological maturity Monetta (79 days) was the earliest, PK 471 (85 days) and Bragg (85 days) were medium in duration. Hardee (89 days)

Table 4.1. Number of days taken to 50 per cent flowering and physiological maturity in different soybean varieties during 1990

Varieties	Number of days taken 50% flowering	Number of days taken to physiological maturity from 50% flowering	Total number of days to physiological maturity
Monetta	33	46	79
PK 471	37	48	85
Bragg	37	48	85
Hardee	40	49	89
KHSb 2	43	50	93
Mean	38	48.2	86.2
F-test	*	----	----
S.Em. _±	0.40	----	----
C.D. at 5%	1.23	----	----
C.V.%	2.17	----	----

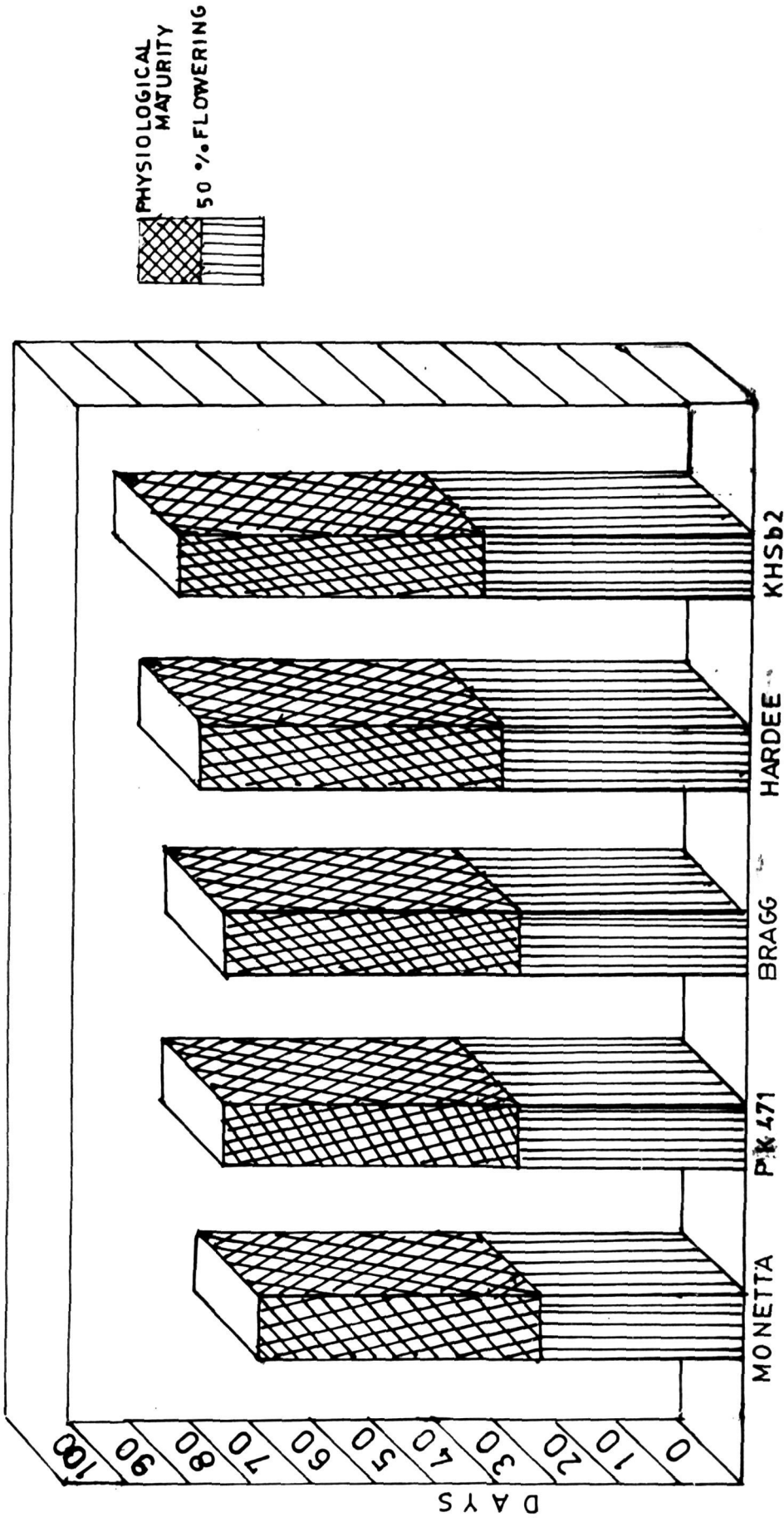


FIG.4.1. NUMBER OF DAYS TAKEN TO 50 PER CENT FLOWERING AND PHYSIOLOGICAL MATURITY IN DIFFERENT SOYBEAN VARIETIES DURING RABI_1990

and KHSb2 (93 days) took more number of days for physiological maturity.

4.1.2 Fresh weight of husk

The results on the fresh weight of husk (g/10 pods) of different varieties at different pod developmental stages are presented in Table 4.2 and graphically illustrated in Fig. 4.2.

(a) **Due to varieties:** The fresh weight of husk differed significantly among the varieties at all sampling stages of pod development. In Monetta the fresh weight of husk increased from 4.60 g/10 pods on 15th day to 4.91 g/10 pods on 40th day from flowering. Afterwards the fresh weight of husk decreased to 1.56 g/10 pods on 52nd day. In PK 471, 4.27 g/10 pods on 15th day to 4.97 g/10 pods on 40th day from flowering. Afterwards it was 1.62 g/10 pods on 52nd day. In Bragg and Hardee 4.16 g/10 pods on 15th day to 5.68 g/10 pods on 42nd day and 4.67 g/10 pods on 15th day to 5.81 g/10 pods on 42nd day. Afterwards it decreased to 2.30 and 1.63, respectively. In KHSb2 4.07 g/10 pods on 15th day to 4.82 g/10 pods on 42nd day. Afterwards the fresh weight of husk decreased to 1.42 g/10 pods on 54th day.

(b) **Due to pod developmental stages**

Table 4.2. Fresh weight of husk (g/10 pods) of different soybean varieties at different pod developmental stages during rabi 1990

Varieties	Days after 50% flowering												
	15	20	25	30	35	40	42	44	46	48	50	52	54
Monetta	4.60	4.63	4.66	4.79	4.89	4.91	3.20	3.58	1.81	1.68	1.57	1.56	---
PK 471	4.27	4.56	4.64	4.71	4.82	4.97	3.30	2.92	2.39	2.21	1.45	1.42	---
Bragg	4.16	4.35	4.36	4.44	4.90	5.43	5.68	4.31	3.94	2.75	2.58	2.30	---
Hardee	4.67	4.74	4.81	5.37	5.39	5.33	5.81	4.02	2.94	2.88	2.45	1.64	1.63
KHSb 2	4.07	4.36	4.37	4.48	4.56	4.78	4.82	3.91	3.12	2.33	1.92	1.40	1.42
Mean	4.35	4.52	4.56	4.78	4.91	5.07	5.56	3.86	3.00	2.47	2.15	1.71	---
F-test	*	*	*	*	*	*	*	*	*	*	*	*	*
S.Em±	0.44	0.30	0.26	0.32	0.30	0.25	0.31	0.21	0.43	0.10	0.11	0.29	0.00
C.D. at 5%	1.35	0.91	0.81	0.98	0.92	0.77	0.94	0.64	1.32	0.31	0.33	0.86	---
C.V.%	2.02	1.30	1.14	0.31	1.33	1.11	1.55	1.28	2.92	2.44	1.02	1.41	---

Irrespective of varieties, the fresh weight of husk was the lowest on 15th day (4.35 g/10 pods) from flowering and it progressively increased and reached its peak (5.56 g/10 pods) on 42nd day and subsequently it decreased (1.71 g/10 pods) on 52nd day from flowering.

4.1.3 Dry weight of husk

The results on the dry weight of husk (g/10 pods) of different soybean varieties at different pod developmental stages are presented in Table 4.3 and graphically illustrated in Fig. 4.2.

(a) **Due to varieties:** The dry weight of husk (g/10 pods) varied significantly among the varieties at all pod developmental stages. At 15th day after 50 per cent flowering, the dry weight of husk was minimum (Monetta: 1.08 g/10 pods, Bragg: 0.82 g/10 pods, Hardee: 0.73 g/10 pods, KHSb2: 0.70 g/10 pods and PK 471: 0.69 g/10 pods) in all varieties.

Maximum dry weight of husk was attained on 40th day in Monetta (1.50 g/10 pods), on 40th day in both PK 471 (1.66 g/10 pods) and Bragg (1.68 g/10 pods) and on 40th day in both Hardee (1.72 g/10 pods) on 42nd day and KHSb2 (1.43 g/10 pods) from 50 per cent flowering.

Generally the dry weights increased gradually from 15 days after 50 per cent flowering till the maximum weight was

Table 4.3. Dry weight of husk (g/10 pods) of different soybean varieties at different pod developmental stages during rabi 1990

Varieties	Days after 50% flowering												
	15	20	25	30	35	40	42	44	46	48	50	52	54
Monetta	1.08	1.15	1.27	1.42	1.36	1.50	1.39	1.36	1.35	1.34	1.34	1.31	---
PK 471	0.69	1.03	1.15	1.16	1.30	1.66	1.51	1.48	1.45	1.43	1.42	1.42	---
Bragg	0.82	0.85	1.07	1.31	1.34	1.68	1.65	1.64	1.52	1.50	1.44	1.44	---
Hardee	0.73	1.15	1.19	1.41	1.47	1.72	1.53	1.50	1.49	1.38	1.52	1.27	1.29
KHSb 2	0.70	0.96	1.07	1.18	1.25	1.26	1.43	1.31	1.29	1.28	1.22	1.18	1.17
Mean	0.80	1.04	1.15	1.35	1.33	1.57	1.58	1.46	1.42	1.41	1.37	1.33	---
F-test	*	*	*	*	*	*	*	*	*	*	*	*	*
S.Em.±	0.13	0.08	0.06	0.13	0.07	0.18	0.08	0.24	0.46	0.09	0.04	0.14	---
C.D.at 5%	0.42	0.24	0.20	0.40	0.21	0.54	0.24	0.73	1.39	0.28	0.28	0.56	---
C.V.%	3.35	1.57	1.16	1.97	1.08	2.56	1.23	3.09	5.14	1.26	1.26	2.61	---

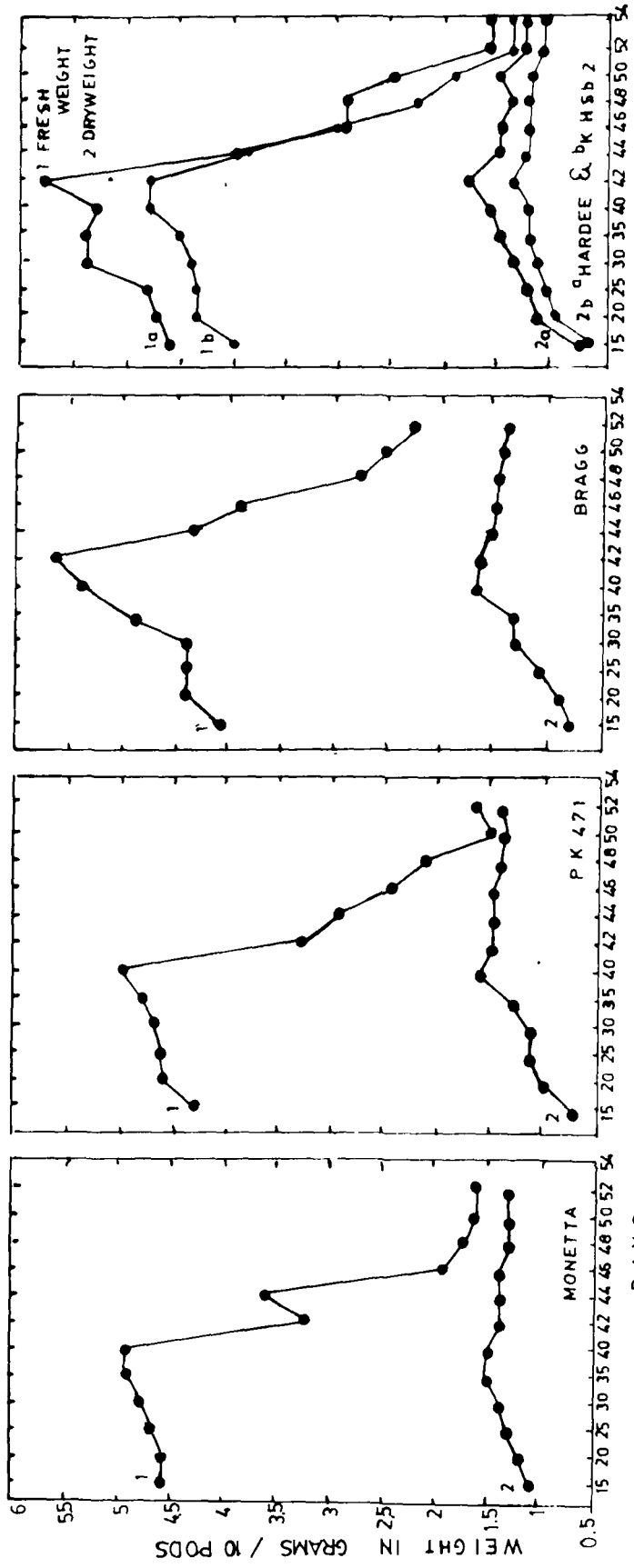


FIG. 4.2. FRESH WEIGHT AND DRY WEIGHT OF HUSK OF 10 PODS OF DIFFERENT VARIETIES OF SOYBEAN, AT DIFFERENT MATURITY STAGES DURING RABI 1990

attained (40 and 42nd day days after 50 per cent flowering) and subsequently it decreased progressively and significantly in all varieties.(b) Due to pod developmental stages:

Irrespective of varieties, the dry weight of husk was the lowest (0.80 g/10 pods) on 15th day from flowering and it progressively increased and reached its peak (1.58 g/10 pods) on 42nd day and subsequently it decreased slightly (1.42 g/10 pods).

4.1.4 Moisture percentage of husk

The data on the moisture percentage of husk of different soybean varieties at different pod developmental stages are presented in Table 4.4 and graphically illustrated in Fig. 4.4.

(a) **Due to varieties:** The moisture percentge differed significantly among the varieties at all stages of pod development from 15th to 52nd from 50 per cent flowering.

The moisture percentage in husk on 15th day after 50 per cent flowering was the highest in Hardee (84.43%) closely followed by PK 471 (83.88%). Monetta recorded the lowest (76.52%) moisture percentage in husk on 15th day after 50 per cent flowering while KHSb2 (82.28%) and Bragg (80.28%) recorded significantly higher than that of Monetta (76.52%)

Table 4.4. Moisture percentage of husk (g/10 pods) of different soybean varieties at different pod developmental stages during rabi 1990

Varieties	Days after 50% flowering												
	15	20	25	30	35	40	42	44	46	48	50	52	54
Monetta	76.52	75.55	73.78	72.77	71.67	70.87	67.98	68.09	31.05	18.21	14.70	14.68	---
PK 471	83.88	77.44	75.07	70.22	69.04	68.71	60.53	55.73	47.22	35.33	25.55	12.47	---
Bragg	80.28	80.34	78.17	74.87	73.27	71.00	62.73	51.23	35.09	33.80	24.82	15.93	---
Hardee	84.43	75.34	75.08	73.63	72.50	71.11	67.59	56.44	48.53	46.38	37.85	22.60	20.65
KHSb 2	82.28	77.89	74.19	70.36	68.58	67.03	65.68	61.23	56.00	51.37	36.21	19.18	17.16
Mean	81.47	77.31	75.25	72.37	71.00	69.74	64.10	54.54	43.57	37.01	27.82	16.97	---
F-test	*	*	+	*	*	*	*	*	*	*	*	*	*
S.Em.±	0.56	0.47	0.46	0.38	0.51	0.44	0.51	0.57	1.26	0.57	0.49	0.36	---
C.D. at 5%	1.71	1.433	1.39	1.16	1.56	1.35	1.56	1.72	3.81	1.72	1.47	1.07	---
C.V.%	1.38	1.23	1.23	1.07	1.45	1.28	1.61	2.09	5.82	3.06	3.47	2.11	---

but lower than Hardee (84.43%) and PK 471 (83.28%).

(b) Due to pod developmental stages: The moisture content of husk was the highest (81.47%) on 15th day from flowering and subsequently it decreased progressively recording a minimum of (16.97%) on 52nd day from flowering.

4.1.5 Fresh weight of seeds

The results on fresh weight of (g/10 pods) seeds of different soybean varieties at different maturity stages of seed development are presented in Table 4.5 and graphically illustrated in Fig 4.3.

(a) Due to varieties: The fresh weight of (g/10 pods) seeds differed significantly among the varieties at all pod developmental stages from 15 to 52nd day after 50 per cent flowering.

On 15th day after flowering, the fresh weights of pods seeds were 0.81 g/10 pods, 0.90 g/10, 0.96 g/10 pods, 0.98 g/10 pods and 1.00 g/10 pods in Monetta, KHSb2, PK 471, Bragg and Hardee, respectively. The fresh weight of seeds increased gradually after 50 per cent flowering in all the varieties. In Monetta the fresh weight of husk increased from 0.81 g/10 pods to 3.12 g/10 pods on 52nd day from flowering. In PK 471 the peak fresh weight of seed (7.33 g/10 pods) was on 46th day from flowering. In Bragg also it

Table 4.5. Fresh weight of seeds (g/10 pods) of different soybean varieties at different pod developmental stages during rabi 1990

Varieties	Days after 50% flowering													
	15	20	25	30	35	40	42	44	46	48	50	52	54	
Monetta	0.81	2.14	4.45	4.49	6.11	6.24	6.54	5.84	4.10	3.90	3.86	3.12	---	
PK 471	0.96	1.57	2.65	3.75	3.89	6.55	6.63	6.93	7.33	6.51	4.54	4.36	---	
Bragg	0.99	1.47	1.74	4.90	6.48	8.27	8.31	8.56	8.59	8.52	7.18	7.42	---	
Hardee	1.00	3.25	3.87	6.38	7.50	7.67	8.59	8.62	8.71	8.82	8.61	7.42	7.41	
KHSb 2	0.90	1.84	2.40	5.31	5.87	5.90	6.44	6.87	6.88	6.92	5.37	4.09	4.60	
Mean	0.93	1.85	3.08	4.96	5.97	7.36	7.39	7.35	7.12	6.93	5.91	4.96	---	
F-test	*	*	*	*	*	*	*	*	*	*	*	*	*	
S.Em.±	0.34	0.57	0.61	0.82	0.91	0.72	0.54	0.53	0.51	0.56	0.28	0.53	---	
C.D. at 5%	1.03	1.73	1.84	2.50	2.74	2.19	1.64	1.60	1.56	1.69	0.86	0.62	---	
C.V.%	5.25	6.20	3.91	3.10	3.00	2.11	1.53	1.64	1.64	1.85	1.10	1.51	---	

was 8.59 g/10 pods at 42nd day. In Hardee the maximum fresh weight (8.82 g/10 pods) was at 48th day. In KHSb2 maximum fresh weight of seed (6.92 g/10 pods) was attained on 48th day from flowering.(b) Due to pod developmental stages:

Irrespective of varieties, the fresh weights of seeds was the lowest (0.93 g/10 pods) on 15th day after 50 per cent flowering and subsequently it reached its maximum (7.12 g/10 pods) on 46th day after flowering and afterwards it gradually declined to 4.96 g/10 pods on 52nd day after 50 per cent flowering.

4.1.6 Dry weight of seeds

The data on the dry weight of seeds of soybean varieties at different pod developmental stages are presented in Table 4.6 and graphically illustrated in Fig. 4.3.

(a) Due to varieties: The dry weight of (g/10 pods) seeds differed significantly among the varieties. Among different varieties, the dry weights of Hardee (4.66 g/10 pods on 50th day after flowering, Bragg (4.24 g/10 pods) on 48th day and PK 471 (3.99 g/10 pods) on 48th day were significantly higher than KHSb2 (3.06 g/10 pods) on 48th day after 50 per cent flowering. The lowest dry weight was recorded in Monetta (2.86 g/10 pods) on 44th day after 50 per cent

Table 4.6. Dry weight of seeds (g/10 pods) of different soybean varieties at different pod developmental stages during rabi 1990

Varieties	Days after 50% flowering												
	15	20	25	30	35	40	42	44	46	48	50	52	54
Monetta	0.10	0.51	1.26	1.31	2.55	2.73	2.75	2.79	2.86	2.58	2.41	2.39	---
PK 471	0.12	0.32	0.72	1.07	1.35	2.45	3.26	3.80	3.94	3.99	3.96	3.83	---
Bragg	0.13	0.19	0.41	1.23	1.90	3.05	3.15	3.93	4.01	4.24	4.23	4.22	---
Hardee	0.16	0.67	0.94	1.89	2.42	2.73	3.25	3.28	4.25	4.59	4.66	4.60	4.59
KHSb 2	0.11	0.35	1.29	1.29	1.77	1.96	2.62	2.90	2.31	3.05	3.06	2.97	2.94
Mean	0.12	0.38	0.92	1.36	1.97	2.58	3.00	3.34	3.47	3.69	3.66	3.59	---
F-test	*	*	*	*	*	*	*	*	*	*	*	*	*
S.Em.+	0.15	0.12	0.16	0.26	0.27	0.35	0.64	0.21	0.24	0.21	0.25	0.36	---
C.D. at 5%	0.46	0.38	0.48	0.80	0.83	1.07	1.95	0.65	0.73	0.63	0.76	1.08	---
C.V.%	1.37	3.49	4.15	3.74	2.80	3.02	4.13	1.46	1.52	1.23	1.40	3.03	---

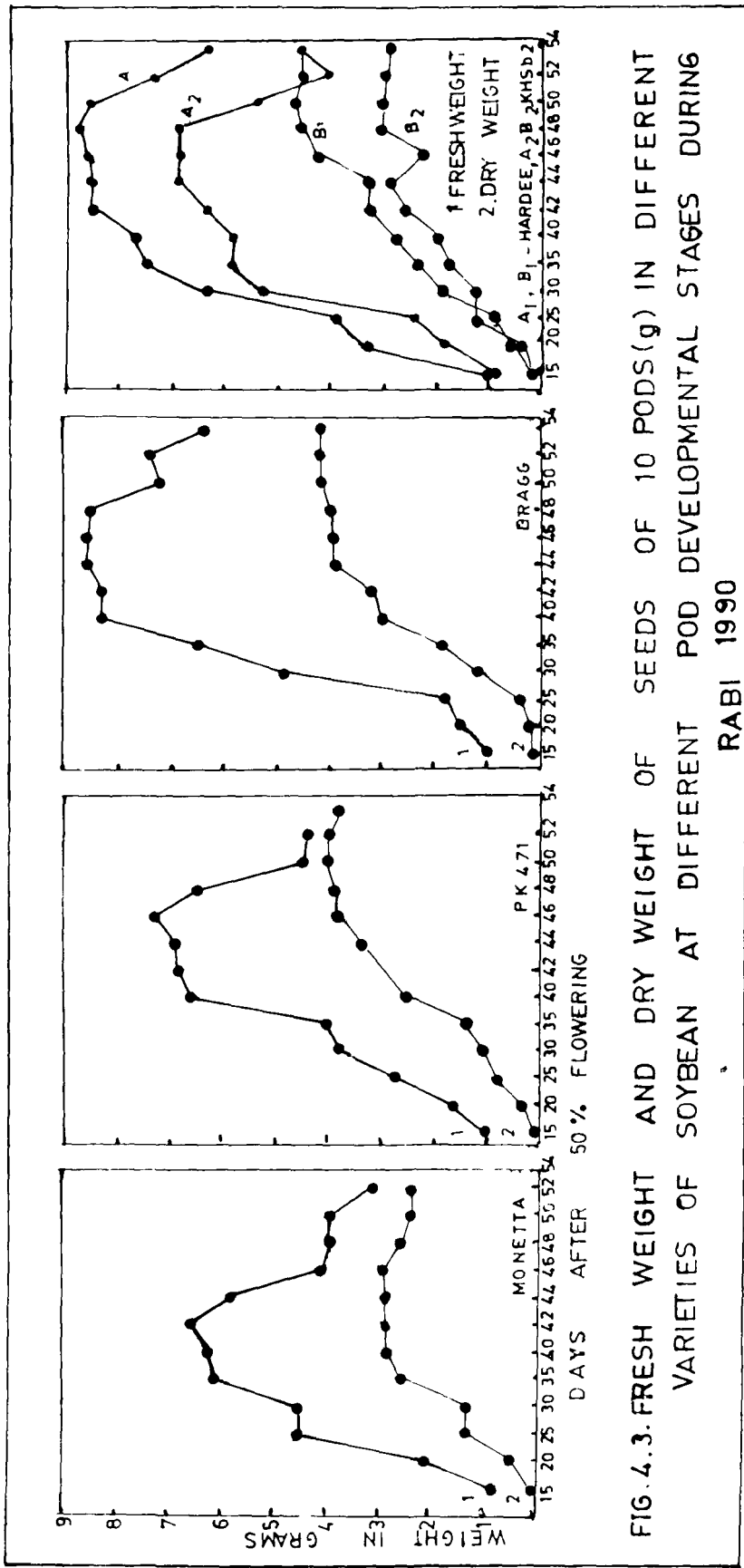


FIG. 4.3. FRESH WEIGHT AND DRY WEIGHT OF SEEDS OF 10 PODS (g) IN DIFFERENT VARIETIES OF SOYBEAN AT DIFFERENT POD DEVELOPMENTAL STAGES DURING RABI 1990

flowering.

The dry weight of seeds (g/10 pods) at physiological maturity in Hardee (4.66 g/10 pods) and Bragg (4.24 g/10 pods) and PK 471 (3.99 g/10 pods) were high. The dry weight of seeds at physiological maturity of KHSb2 (3.06 g/10 pods) was significantly lower than Hardee and Bragg. The lowest dry weight of (g/10 pods) was recorded in Monetta (2.86 g) at physiological maturity.

(b) Due to pod developmental stages:

Irrespective of varieties, the dry weight of seeds was the lowest (0.12 g/10 pods) on 15th day after 50 per cent flowering and it attained its maximum (3.69 g/10 pods) on 48th day and there after it slightly decreased.

4.1.7 Moisture percentage of seeds

The data on the moisture percentage of seeds of different varieties of soybean at different stages of pod and seed development are presented in Table 4.7 and graphically illustrated in Fig. 4.4.

(a) Due to varieties:

The moisture percentage differed significantly among varieties at all maturity stages of seed development. The moisture percentage of PK 471 (87.56 to 24.05%), Hardee

Table 4.7. Moisture percentage of seeds in different soybean varieties at different pod developmental stages during rabi 1990

Varieties	Days after 50% flowering													
	15	20	25	30	35	40	42	44	46	48	50	52	54	
Monetta	86.41	76.16	72.13	70.64	59.06	58.20	51.10	37.45	32.15	27.24	23.34	22.98	---	
PK 471	87.56	79.64	74.60	71.29	67.74	63.08	58.85	55.22	49.53	44.52	39.09	24.05	---	
Bragg	84.32	81.00	76.40	73.84	70.61	63.47	61.64	59.65	54.59	50.21	33.24	27.89	---	
Hardee	86.82	79.17	75.59	70.23	68.89	64.33	62.17	59.13	53.20	48.49	41.81	29.76	27.57	
KHSb 2	84.40	80.61	77.92	75.59	69.73	64.89	59.31	57.80	56.87	55.86	43.82	27.17	24.94	
Mean	85.75	79.31	75.32	72.33	67.20	62.79	58.61	53.85	48.46	44.46	36.26	36.37	---	
F-test	*	*	*	*	*	*	*	*	*	*	*	*	*	
S.Em.±	0.54	0.36	0.52	0.42	0.50	0.58	0.51	1.60	0.48	0.35	0.86	0.59	---	
C.D. at 5%	1.55	1.08	1.58	1.27	1.51	1.75	1.55	5.79	1.44	1.07	2.59	1.60	---	
C.V.%	1.20	0.90	1.40	1.16	1.49	1.87	1.83	4.84	1.98	1.61	4.84	1.98	---	

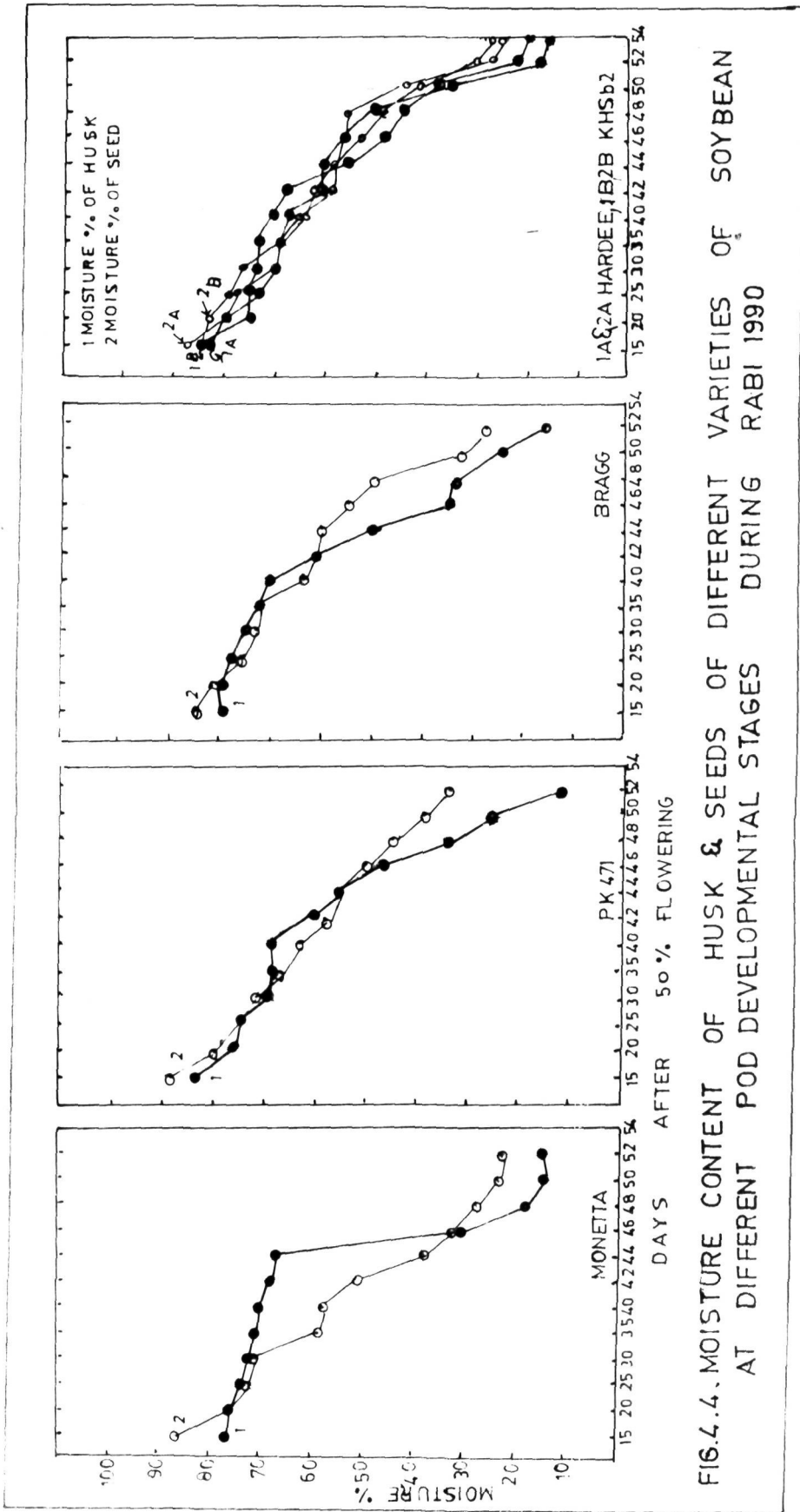


FIG.4.4. MOISTURE CONTENT OF HUSK & SEEDS OF DIFFERENT VARIETIES OF SOYBEAN AT DIFFERENT POD DEVELOPMENTAL STAGES DURING RABI 1990

(86.82 to 27.57%) and Monetta (86.41 to 22.98%) were significantly higher than KHSb2 (84.40 to 24.94%) and Bragg (84.32 to 24.05%) at different stages of seed development.

The moisture percentage at physiological maturity of Bragg (50.21%), PK 471 (49.53%) and Hardee (48.49%) were significantly higher than that of KHSb2 (43.82%) and Monetta (32.15%). The lowest percentage of moisture content at physiological maturity was recorded by Monetta (32.15%).

(b) Due to pod developmental stages:

Irrespective of varieties, the seed moisture was the highest (85.75%) at 15 days from 50 per cent flowering and it gradually declined to 26.37 per cent at 52nd day from 50 per cent flowering.

4.1.8 Dry matter accumulation in husk and seeds

Dry matter distribution in husk and seeds (per cent to total) at different developmental stages of pod are presented in Table 4.8 and graphically illustrated in Fig. 4.5.

(a) Due to varieties:

The dry matter distribution in the husk (per cent to total) was the highest in the beginning and with advance in age it decreased. In Monetta it was 86.89 per cent in the

Table 4.8. Dry matter distribution in husk and seeds (per cent to total) of different varieties of soybean at different developmental stages of pod during rabi 1990

Varieties	Days after 50% flowering												
	15	20	25	30	35	40	42	44	46	48	50	52	54
Monetta													
Husk %	86.98	69.27	52.14	50.77	40.75	38.54	36.79	30.87	29.35	37.32	27.92	27.91	---
Seed %	13.11	30.73	47.86	48.23	49.24	61.46	63.21	69.18	70.65	72.68	72.08	72.09	---
PK 471													
Husk %	81.71	76.28	67.83	56.76	50.15	45.25	36.57	34.76	32.35	28.22	26.09	25.88	---
Seed %	18.29	23.72	32.17	43.24	49.85	54.75	63.43	65.24	67.65	71.78	73.91	74.12	---
Bragg													
Husk %	87.69	78.48	72.31	55.78	40.76	34.02	32.34	31.76	30.74	30.07	28.82	28.23	---
Seed %	12.31	21.52	27.69	44.22	59.24	65.98	67.66	68.24	69.26	69.93	71.18	72.77	---
Hardee													
Husk %	88.24	64.07	55.91	42.82	37.18	37.14	34.42	32.34	31.34	30.56	30.54	29.08	28.02
Seed %	11.76	35.93	44.09	57.18	62.72	63.86	65.58	67.66	68.73	69.42	69.46	70.92	71.98
KHSb 2													
Husk %	86.03	72.86	66.94	47.67	41.41	38.79	31.79	30.68	29.03	28.97	28.86	28.16	28.15
Seed %	13.97	27.14	33.06	52.33	58.59	61.21	68.21	69.32	71.97	71.03	71.14	71.84	71.84
Mean :Husk %	86.12	72.19	63.03	50.76	46.86	38.75	34.38	32.08	30.57	29.03	27.44	27.42	---
Mean :Seed %	13.88	27.81	36.97	49.24	53.14	61.25	65.62	67.92	69.43	70.97	72.56	72.58	---

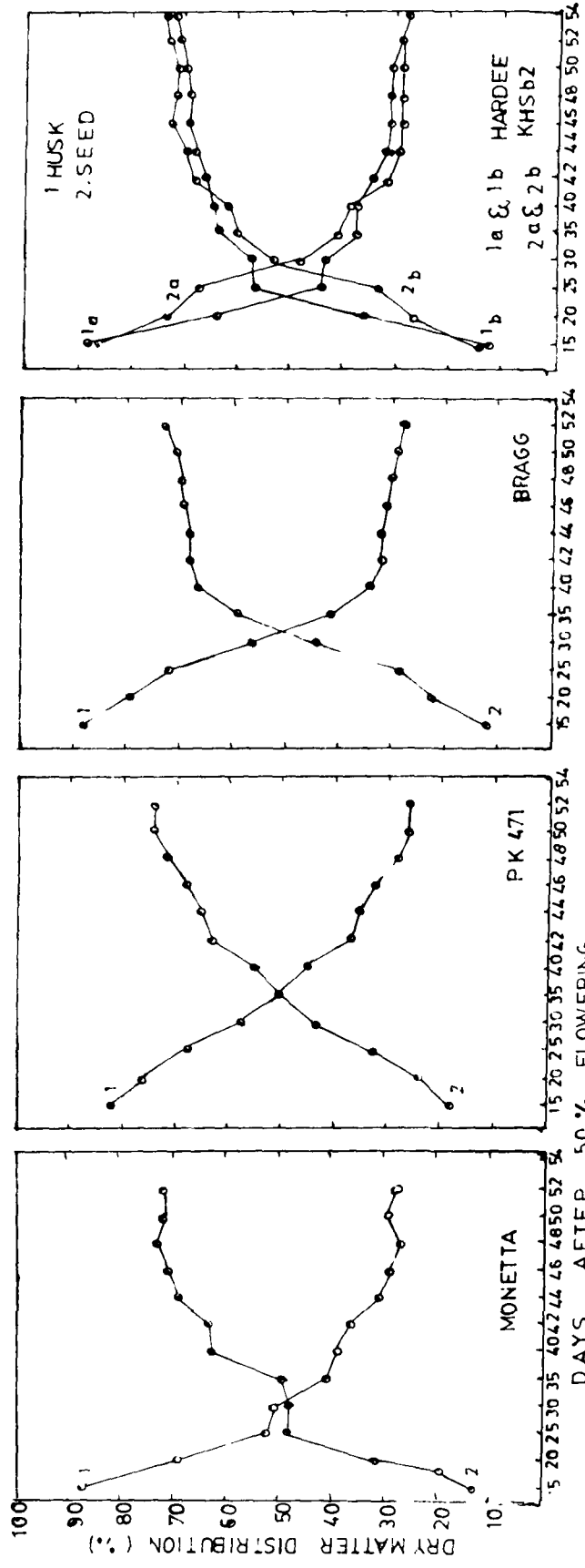


FIG.4.5. DRY MATTER DISTRIBUTION IN HUSK AND SEEDS (Per Cent To Total) OF DIFFERENT VARIETIES OF SOYBEAN AT DIFFERENT DEVELOPMENTAL STAGES OF PODS DURING RABI 1990

beginning and at 52nd day it decreased to 27.91 per cent. In PK 471 it decreased from 81.71 to 25.88 per cent. In Bragg it decreased from 87.69 to 28.33 per cent. In Hardee, it decreased from 88.24 to 28.02 per cent. In KHSb2, it decreased from 86.03 to 28.15 per cent.

The dry matter distribution into the seed in all varieties progressively increased with advance in age. In Monetta the dry matter distribution into the seed increased from 13.11 to 72.09 per cent. In PK 471 it increased from 18.29 to 74.12 per cent. In Bragg it was from 12.31 to 72.77 per cent. In Hardee it increased from 11.76 to 71.98 per cent. In KHSb2 it increased from 13.97 to 71.84 per cent.

(b) Due to pod developmental stages:

The dry matter distribution into the husk progressively decreased with advance in age from 86.12 to 27.42 per cent) whereas in seed it progressively increased from 13.88 to 72.58 per cent.

4.1.9 Germination percentage of developing seeds

The results on the germination percentage of developing seed of soybean varieties are presented in Table 4.9 and graphically illustrated in Fig 4.6.

(a) Due to varieties:

Table 4.9. Germination percentage of developing seeds of soybean varieties at different pod developmental stages during rabi 1990

Varieties	Days after 50% flowering												
	15	20	25	30	35	40	44	46	48	50	52	54	
Monetta	---	---	---	---	14.50	48.25	70.00	89.00	99.50	99.25	99.25	99.25	---
PK 471	---	---	---	---	11.25	50.50	73.50	84.00	98.00	99.50	99.00	99.00	---
Bragg	---	---	---	---	10.50	44.50	74.08	90.00	98.50	100.00	99.75	99.75	---
Hardee	---	---	---	---	13.50	48.50	73.00	86.00	92.00	99.75	99.75	99.50	99.50
KHSb 2	---	---	---	---	9.50	37.50	54.50	81.50	86.00	97.50	100.00	99.75	99.50
Mean	---	---	---	---	11.75	45.85	83.80	86.10	94.80	98.90	99.55	99.45	---
F-test	---	---	---	---	NS	NS	*	*	*	*	*	*	---
S.Em.±	---	---	---	---	---	1.95	2.14	0.80	0.80	0.35	0.33	0.31	---
C.D. at 5%	---	---	---	---	---	5.89	6.43	2.42	1.08	0.99	0.93	0.93	---
C.V.%	---	---	---	---	---	5.52	4.88	1.68	0.72	0.62	0.59	0.59	---

From 15 to 30th day after flowering, the developing seeds did not germinate. The germination percentage of developing seeds was recorded only after 35 days from flowering. In Monetta the germination increased from 14.50 to 99.50 per cent at 46th day from flowering. In PK 471 the peak germination was on 48th day from flowering (99.5%). In Bragg and KHSb2 100 per cent was recorded at 48th day and 50th day from 50 per cent flowering.

(b) Due to pod developmental stages:

Irrespective of varieties the developing seeds (ovules) did not germinate upto 30 days from flowering on 35th day from flowering. The germination percentage was the lowest (11.75%) on 35th day after 50 per cent flowering and reached its peak (99.55 per cent) on 50th day from flowering.

4.1.10 a Vigour index of soybean seeds (mean length of seedling X germination percentage)

The results on the vigour index of soybean seeds sampled at different stages of developing seeds are presented in Table 4.10 a and graphically illustrated in Fig. 4.6.

(a) Due to varieties:

The vigour index of developing seeds increased only

Table 4.10 a. Vigour index (mean root length of root + shoot X germination percentage) of different varieties of soybean seeds harvested at different maturity stages of pods during rabi 1990

Varieties	Days after 50% flowering												
	15	20	25	30	35	40	42	44	46	48	50	54	
Monetta	---	---	---	---	307	1615	2576	2849	3081	3056	3052	3051	---
PK 471	---	---	---	---	247	1712	2498	2994	2996	2998	2992	2987	---
Bragg	---	---	---	---	184	1491	2499	2996	3070	3125	3024	3021	---
Hardee	---	---	---	---	298	1316	1964	2618	2887	3025	3084	2998	2991
KHSb 2	---	---	---	---	203	795	1066	2728	2972	3137	3165	3094	3083
Mean	---	---	---	---	248	1386	2077	2836	2984	3192	3163	3130	---
F-test	---	---	---	---	NS	*	*	*	*	*	*	*	---
S.Em.±	---	---	---	---	---	100.09	105.85	105.12	106.02	146.0	152.2	148.1	---
C.D. at 5%	---	---	---	---	---	313.70	319.02	319.22	319.53	140.0	458.7	442.3	---
C.V.%	---	---	---	---	---	15.01	10.00	8.42	7.36	10.0	10.3	10.6	---

Table 4.10 b. Vigour index (mean dry weight of seedling (g) X germination percentage) of different varieties of soybean seeds harvested at different maturity stages of pods during rabi 1990

Varieties	Days after 50% flowering												
	15	20	25	30	35	40	42	44	46	48	50	52	54
Monetta	---	---	---	---	0.38	1.32	2.29	3.48	4.74	4.70	4.35	4.34	---
PK 471	---	---	---	---	0.48	2.22	3.62	4.60	4.13	4.98	4.29	4.27	---
Bragg	---	---	---	---	0.43	2.38	4.33	5.07	5.27	4.52	5.24	5.20	---
Hardee	---	---	---	---	0.60	2.38	3.34	5.39	4.41	4.52	5.56	5.21	4.21
KHSb 2	---	---	---	---	0.26	1.08	1.80	4.21	4.66	5.24	5.28	4.19	4.17
Mean	---	---	---	---	0.43	1.89	3.08	4.67	4.64	4.97	4.94	4.64	---
F-test	---	---	---	---	NS	*	*	*	*	*	*	**	---
S.Em.±	---	---	---	---	---	0.15	0.20	0.31	0.13	0.14	0.15	0.16	---
C.D. at 5%	---	---	---	---	---	0.46	0.61	0.95	0.39	0.42	0.46	0.49	---
C.V.%	---	---	---	---	---	0.38	3.29	3.59	5.54	5.82	6.24	6.91	---

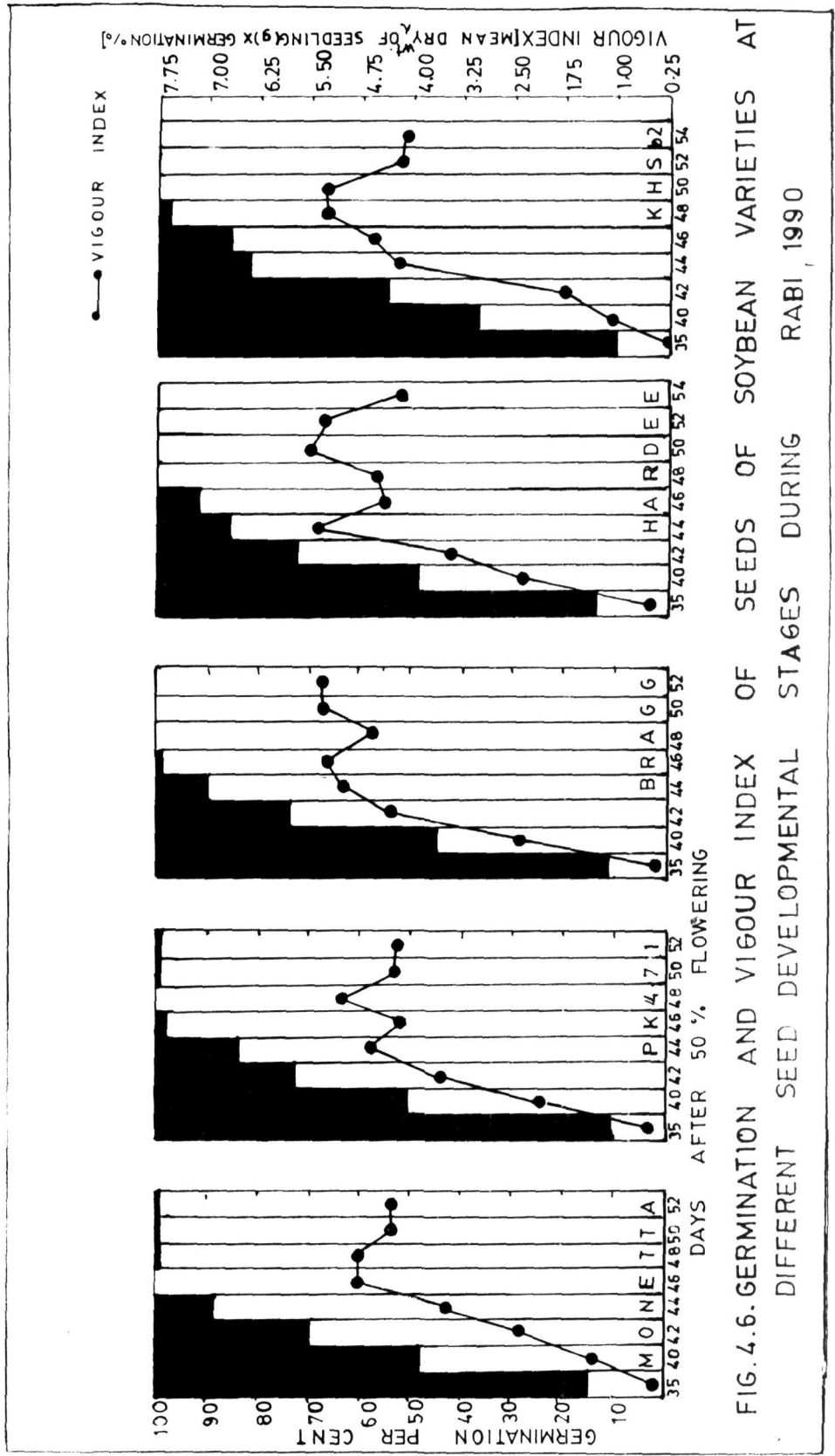


FIG. 4.6. GERMINATION AND VIGOUR INDEX OF SEEDS OF SOYBEAN VARIETIES AT DIFFERENT SEED DEVELOPMENTAL STAGES DURING RABI, 1990

from 35 to 50th day after flowering. In Monetta the vigour index increased from 307 to 3081 after 46th day from flowering. In PK 471 the peak vigour index on 48th day from flowering was (2998). In Bragg also it was 3125 after 48th day from flowering. In Hardee the maximum was (3084) at 50th day from flowering. In KHSb2 maximum (3165) vigour index was attained in 50th day from flowering.

(b) Due to seed developmental stages:

There was a significant increase in vigour index of all the varieties from 35 to 52nd day after 50 per cent flowering. The vigour index was the lowest (248) on 35th day from flowering and it progressively increased and reached its peak 3192 on 50th day and subsequently it decreased (3130) on 52nd day from flowering.

4.1.10 b: Vigour index of soybean seeds (mean dry weight of seedling X Germination percentage)

The results on the vigour index of soybean seeds sampled at different stages of pod development are presented in Table 4.10 b and graphically illustrated in Fig. 4.6.

(a) Due to varieties:

The vigour index increased significantly only from 40th to 52nd day from 50 per cent flowering. In Monetta the vigour index increased from 0.38 at flowering to 4.74 at

46th day from flowering. In PK 471 the peak vigour index was (4.98) on 48th day from flowering. In Bragg also it was (5.52) at 48th day from flowering. In Hardee, the vigour index was maximum (5.56) at 50th day from flowering. While in KHSb2 the vigour index was maximum (5.28) on 50th day from flowering.

(b) Due to seed developmental stages:

The vigour index was the lowest (0.43) on 35th day from flowering and it progressively increased and reached its peak (4.99) on 50th day and subsequently it decreased progressively recording a minimum of (4.64) 52nd day from flowering.

4.1.11. Mean pod length

The data on mean pod length of different varieties at maturity stages of pod are presented in Table 4.11 and graphically illustrated in Fig 4.7.

The mean pod length did not differ significantly among the varieties. It ranged from 3.65 to 4.6 cm. The pod length in KHSb2 (4.3 cm) and Hardee (4.27 cm) was more than others. In Bragg (4.15 cm) it was medium. However, the pod length in Monetta (3.65 cm) and PK 471 (3.90 cm) was shorter than others.

Table 4.11. Mean pod length (cm) of different soybean varieties at maturity stages of pod during rabi 1990

Varieties	Mean pod length
Monetta	3.65
PK 471	3.90
Bragg	4.15
Hardee	4.27
KHSb 2	4.30
Mean	4.05
F-test	NS
S.Em. _±	--
C.D. at 5%	--
C.V.%	--

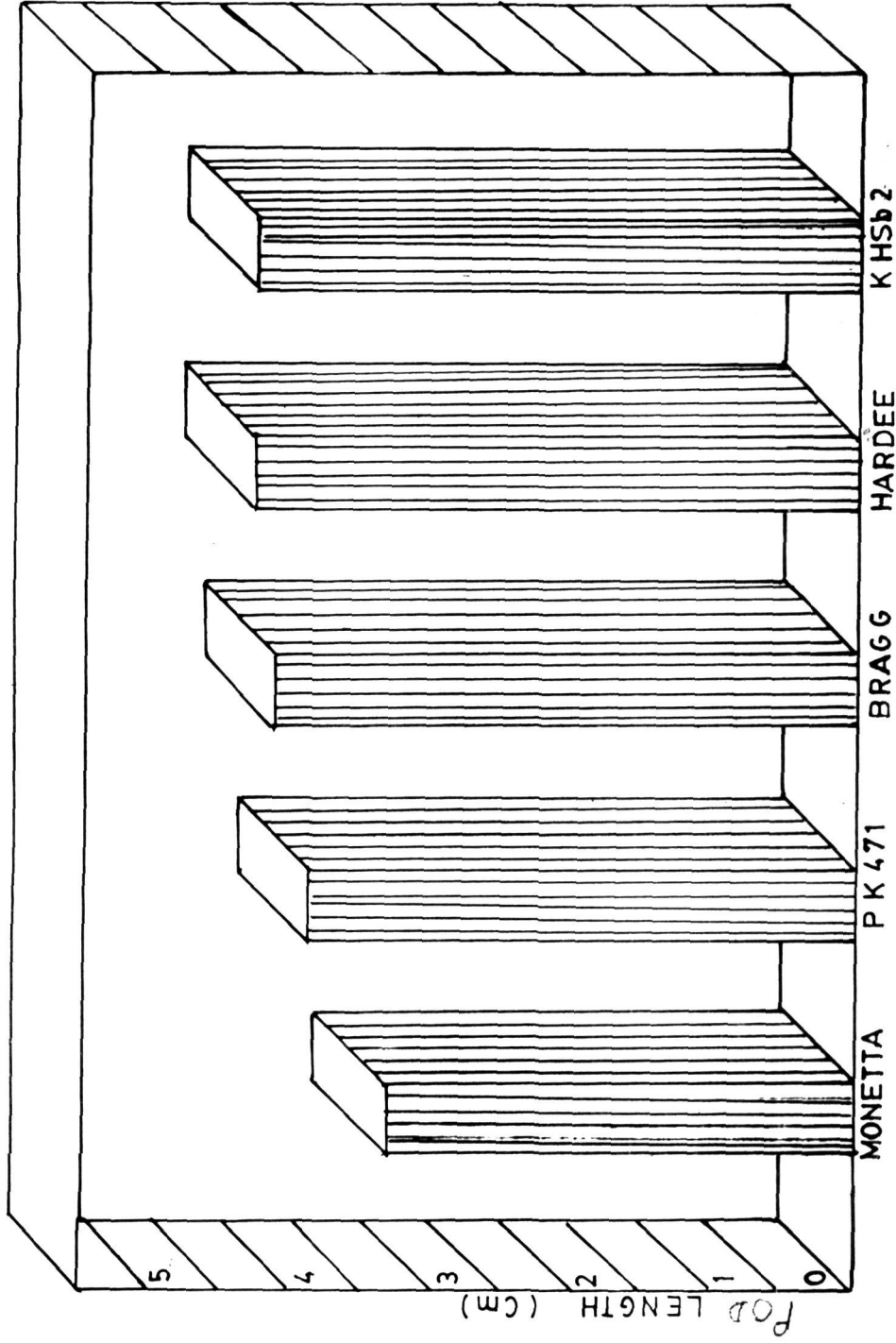


FIG.4.7. MEAN POD LENGTH OF DIFFERENT SOYBEAN VARIETIES DURING RABI, 1990

4.2 Studies on the Effects of Harvesting Stages in Soybean Varieties

4.2.1 Studies of pod shattering

The data on pod shattering in the field (percentage of pods shattered per plant) as influenced by varieties and harvesting stages are presented in Table 4.12 and graphically illustrated in Fig. 4.8.

(a) Due to varieties:

Irrespective of harvesting stages, the percentage of pod shattering was the highest in Monetta (38.0%), medium in KHSb2 (16.2%) and Hardee (14.4%) and the lowest in PK 471 (7.7%) and Bragg (4.0%).

(b) Due to harvesting stages:

The field shattering was almost nil in H1, (25% of pods in yellow colour), H2 (50% of pods in yellow colour) and H3 (75% of pods in yellow colour) harvesting stages. However, shattering of pods began only from H4 (beginning of shattering of pods) and it was the maximum in H8 (12 days after first shattering). On an average of all varieties, the shattering was the least (5.1%) in H4. With further delay in harvestings by 3 (H5), 6 (H6), 9 (H7) and 12 days (H8) after first shattering, it increased to 7.8, 16.2, 22.9 and 28.4%, respectively.

Table 4.12. Percentage of pod/plant shatered in different varieties of soybean as influenced by different harvesting stages during rabi 1990

Treatments	Varieties					Mean
	Monetta	PK471	Bragg	Hardee	KHSb2	
Harvesting stages						
#1 (25% pods/plant in yellow colour)	---	---	---	---	---	---
#2 (50% pods/plant in yellow colour)	---	---	---	---	---	---
#3 (75% pods/plant in yellow colour)	---	---	---	---	---	---
#4 (Beginning of shattering)	11.28	3.76	2.90	4.93	2.57	5.05
#5 (3 days after Ist shattering)	13.73	6.11	3.49	9.48	6.14	7.79
#6 (6 days after Ist shattering)	46.20	7.49	3.89	13.44	9.93	16.19
#7 (9 days after Ist shattering)	55.14	8.98	4.05	16.74	29.37	22.86
#8 (12 days after Ist shattering)	63.67	11.93	5.57	27.78	32.99	28.38
Mean	38.00	7.65	3.98	14.43	16.19	16.05
F-test	*	NS	NS	*	*	*
S.Em. ±	4.28	---	---	2.576	2.853	---
C.D. at 5%	12.92	---	---	7.760	8.59	---
C.V. %	2.25	---	---	5.56	3.52	---

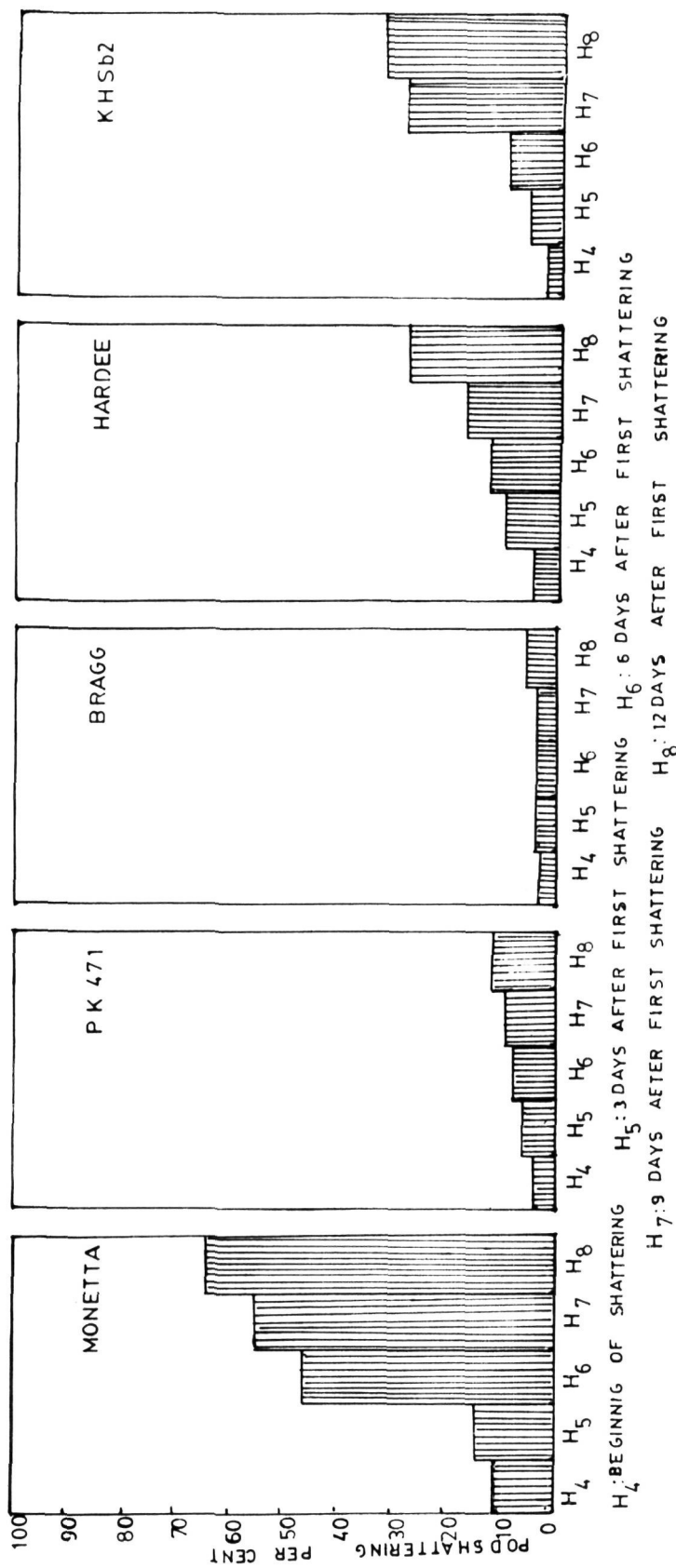


FIG.4.8. POD SHATTERING IN DIFFERENT SOYBEAN VARIETIES AS INFLUENCED BY DIFFERENT HARVESTING STAGES DURING RABI.1990

(c) Interaction effects:

All varieties did not shatter even when 75 per cent of the pods per plant turned yellow in colour. However, Monetta recorded more (11.3%) even from the beginning of shattering (H4) and reached a peak of (64%) after a lapse of 12 days from first shattering. KHSb2 and Hardee were the next varieties susceptible to shattering (2.6 to 33%) and (4.7 to 27.8%), respectively. Bragg (2.9 to 5.57%) and PK 471 (3.8 to 11.9%) recorded low shattering of the pods even after 12 days delay. Field shattering of the pods was the least in Bragg (5.6%) followed by PK 471 (11.93%).

4.2.2 Test weight of 100 seeds

The test weight of 100 seeds (g) in different varieties of soybean as influenced by different harvesting stages are presented in Table 4.13 and graphically illustrated in Fig. 4.9.

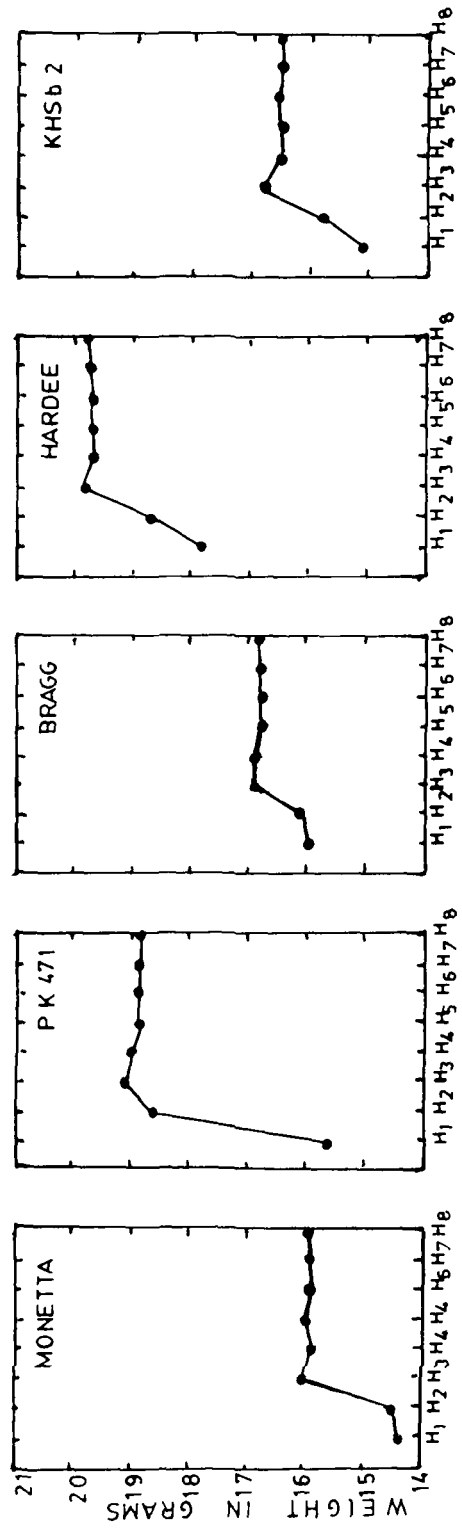
(a) Due to varieties:

Among the varieties, Monetta (15.02 g) recorded the lowest 100 seeds weights. It was medium in Bragg (16.63 g) and KHSb2 (16.24). In Hardee (19.34 g) and PK 471 (18.73g) the 100 seed weight was the highest.

(b) Due to harvesting stages:

Table 4.13 Dry weight of 100 seeds (g) in five soybean varieties as influenced by harvesting stages

Treatments	Varieties					Mean
	Monetta	PK471	Bragg	Hardee	KHSb2	
Harvesting stages						
H1 (25% pods/plant in yellow colour)	14.26	15.57	15.98	17.83	15.06	16.41
H2 (50% pods/plant in yellow colour)	14.44	18.60	16.19	18.67	15.81	16.74
H3 (75% pods/plant in yellow colour)	15.99	19.17	16.88	19.78	16.75	17.71
H4 (Beginning of shattering)	15.87	18.95	16.87	19.71	16.49	17.57
H5 (3 days after 1st shattering)	15.88	18.93	16.81	19.68	16.48	17.37
H6 (6 days after 1st shattering)	15.87	18.88	16.76	19.68	16.47	17.32
H7 (9 days after 1st shattering)	15.86	18.87	16.76	16.67	16.47	17.32
H8 (12 days after 1st shattering)	15.86	18.87	16.75	19.66	16.46	17.32
Mean	15.02	18.73	16.63	19.34	16.24	17.19
F-test	*	*	*	*	*	*
S.E.m. _t	0.16	0.08	0.18	0.13	0.02	0.02
C.D. at 5%	0.47	0.06	0.57	0.04	0.04	0.04
C.V. %	0.13	0.12	0.14	0.11	0.11	0.11



H1: 25% PODS IN YELLOW COLOUR H2: 50% PODS IN YELLOW COLOUR H3: 75% PODS IN YELLOW COLOUR
 H4: BEGINNING OF POD SHATTERING H5: 3 DAYS AFTER FIRST SHATTERING (D.A.F.S) H6: 6 D.A.F.S H7: 9 D.A.F.S
 H8: 12 D.A.F.S

FIG.4.9. DRY WEIGHT OF 100 SEEDS IN FIVE VARIETIES OF SOYBEAN AS INFLUENCED BY HARVESTING STAGES DURING RABI, 1990

The test weight of 100 seeds was the lowest (16.14 g) and 16.74 g respectively in H1 (25% at pods in yellow colour) and in H2 (50% of pods in yellow colour). It was the highest (17.71 g) in H3 (75% of pods in yellow colour). It was medium 17.57 g in H4 (the beginning of shattering). The 100 seeds weight (17.37g, 17.32 g, 17.32 g and 17.32 g respectively) was slightly reduced in 3 days (H5), 6 days (H6), 9 days (H7) and 12 days (H8) after first shattering.

(c) Due to interaction effects:

In Monetta the 100 seed weight was low in H1 (14.26 g) and H2 (14.44 g). It was the highest in H3 (15.99 g). It was medium in H4 (15.87 g). The 100 seed weight decreased (15.98 g, 15.87 g, 15.86 g and 15.86 g respectively). If there was delayed by 3 days (H5), 6 days (H6), 9 days (H7) and 12 days (H8) in harvesting from first shattering. In Bragg the 100 seed weight was low 15.98 g in H1 and 15.98 g and H2 (16.19 g). It was the highest in H3 (16.88 g), it was medium in H4 (16.87 g). The 100 seed weight was reduced if there was delay in harvesting from H5 (16.81 g) to H8 (16.75 g). In KHSb2 the 100 seed weight was low in H1 (15.06 g) and in H2 (15.81 g). It was the highest in H3 (16.75 g). It was medium in H4 (16.49 g). The 100 seed weight was reduced if there was delay in harvesting from H5

(16.48 g) to H8 (16.46 g). In PK 471 the 100 seed weight was low in H1 (17.57 g) and in H2 (18.60 g). It was the highest in H3 (19.17 g). It was medium in H4 (18.95 g). The 100 seed weight was reduced if there was delay in harvesting from H5 (18.93 g) to H8 (18.87 g). In Hardee the 100 seed weight was low in H1 (17.83 g) and in H2 (18.67 g). It was the highest in H3 (19.78 g). It was medium in H4 (19.71 g). The 100 seed weight was reduced if there was delay in harvesting from H5 (19.68 g) to H8 (19.66 g).

4.3 Studies on the Effects of Harvesting Stages on the Storability of Soybean Seeds

The results of storage studies as influenced by varieties, harvesting stages and storage period are presented.

4.3.1 Germination behaviour in storage

The data on lab germination of different varieties as influenced by harvesting stages during the storage period of eight months are presented in Tables 4.14a, 4.14b, 14c, 4.14d and 14e, respectively.

(a) Due to varieties:

The lab germination of different varieties differed significantly as influenced by harvesting stages during storage. The germination progressively decreased in all

Table 4.14 a. Lab germination (per cent) in soybean variety Monetta as influenced by harvesting stages during storage period (Jan-Aug 1991)

Treatments	Storage period (days)								
	0	30	60	90	120	150	180	210	240
Harvesting stages									
H1 (25% pods/plant in yellow colour)	72.5	72.2	71.5	69.5	67.5	65.2	62.2	59.2	55.0
H2 (50% pods/plant in yellow colour)	85.2	85.0	84.0	83.0	81.2	79.0	77.0	74.0	70.5
H3 (75% pods/plant in yellow colour)	99.2	99.0	99.0	99.0	98.0	97.0	97.0	96.5	94.2
H4 (Beginning of shattering)	99.0	99.0	99.0	98.0	97.2	96.0	95.0	94.0	92.0
H5 (3 days after 1st shattering)	99.0	98.2	98.2	98.0	97.6	96.0	95.0	93.0	91.0
H6 (6 days after 1st shattering)	98.5	98.0	98.0	97.2	96.0	95.0	94.0	92.0	90.0
H7 (9 days after 1st shattering)	98.0	98.0	98.0	97.0	96.0	95.0	93.0	91.0	89.0
H8 (12 days after 1st shattering)	98.0	98.0	97.0	97.0	96.0	94.0	92.0	90.0	88.0
Mean	94.2	93.0	93.9	92.3	91.1	89.6	88.1	86.2	83.7
F-test	*	*	*	*	*	*	*	*	*
S.Em. \pm	0.31	0.33	0.47	0.40	0.34	0.52	0.45	0.35	0.29
C.D. at 5%	0.91	0.96	1.38	1.18	1.01	1.54	1.27	1.04	0.87
C.V. %	0.67	0.70	1.02	0.87	0.76	1.17	0.98	0.82	0.69

Table 4.14 b. Lab germination (per cent) in soybean variety PK 471 as influenced by harvesting stages during storage period (Jan to Aug 1991)

Treatments	Storage period (days)								
	0	30	60	90	120	150	180	210	240
Harvesting stages									
H1 (25% pods/plant in yellow colour)	72.5	72.0	70.5	68.0	67.2	65.0	62.25	58.0	54.2
H2 (50% pods/plant in yellow colour)	84.25	82.3	82.2	79.0	81.2	79.0	77.0	74.0	70.2
H3 (75% pods/plant in yellow colour)	99.25	99.0	99.0	99.6	98.0	96.2	95.0	94.5	93.0
H4 (Beginning of shattering)	99.00	99.0	99.0	98.2	97.5	96.5	94.0	93.2	91.0
H5 (3 days after 1st shattering)	99.00	99.0	99.0	98.0	97.0	96.0	95.0	94.0	92.0
H6 (6 days after 1st shattering)	99.00	98.0	98.0	97.6	96.0	96.0	95.0	93.0	91.0
H7 (9 days after 1st shattering)	98.00	98.0	97.0	97.0	96.0	95.0	94.0	92.0	90.0
H8 (12 days after 1st shattering)	98.00	98.0	97.0	96.0	95.0	94.0	93.0	91.0	89.0
Mean	93.60	93.4	92.7	91.5	90.9	89.9	88.5	86.9	83.8
F-test	*	*	*	*	*	*	*	*	*
S.Em. ±	0.51	0.44	0.42	0.71	0.64	0.78	0.71	0.5	0.49
C.D. at 5%	1.50	1.30	1.29	2.05	1.89	0.25	2.08	1.59	1.46
C.V. %	1.10	0.96	0.96	1.55	1.13	1.72	1.63	1.26	1.12

Table 4.14 C. Lab germination (per cent) in soybean variety Bragg as influenced by harvesting stages during storage period (Jan to Aug 1991)

Treatments	Storage period (days)								
	0	30	60	90	120	150	180	210	240
Harvesting stages									
H1 (25% pods/plant in yellow colour)	73.5	73.2	72.2	70.2	68.2	66.0	62.2	58.0	53.5
H2 (50% pods/plant in yellow colour)	86.0	85.0	84.0	83.0	81.0	79.0	76.0	73.0	69.0
H3 (75% pods/plant in yellow colour)	99.2	99.0	99.0	98.2	98.0	97.0	97.0	96.0	94.0
H4 (Beginning of shattering)	99.0	99.0	99.0	98.0	97.0	96.0	95.0	94.0	93.0
H5 (3 days after 1st shattering)	99.0	98.0	98.0	98.0	97.0	96.0	95.0	94.0	92.0
H6 (6 days after 1st shattering)	98.2	98.0	97.0	97.0	96.2	95.0	94.0	93.0	92.0
H7 (9 days after 1st shattering)	98.0	98.0	97.0	97.0	95.0	95.0	94.0	93.0	91.0
H8(12 days after 1st shattering)	98.0	98.0	97.0	96.0	95.0	94.0	93.2	91.0	90.0
Mean	93.8	93.5	92.9	92.1	90.8	87.7	88.3	86.5	84.6
F-test	*	*	*	*	*	*	*	*	*
S.Em.+	0.37	0.37	0.58	0.64	0.64	0.65	0.61	0.67	0.49
C.D. at 5%	1.10	0.07	1.71	1.85	1.87	1.91	1.75	1.95	1.43
C.V. %	0.80	0.78	1.27	1.38	1.41	1.46	1.35	1.54	1.09

varieties in storage from 0 to 240 days. It decreased from 94.2 to 83.7 per cent in Monetta, from 93.6 to 83.8 per cent in PK 471, from 93.8 to 84.6 per cent in Bragg, from 94.3 to 83.5 per cent in Hardee and from 93.3 to 83.8 per cent in KHSb2.

(b) Due to harvesting stages:

Irrespective of varieties, the lab germination both in the beginning and after 240 days of storage was significantly the lowest in H1 and H2. The lab germination both in the beginning and at the end was fairly high and satisfactory (above 90 per cent) in H3 (harvesting when 75% of pods in yellow colour), H4 (the beginning of shattering), in 3 days (H5), 6 days (H6) and 9 days (H7) after first shattering. In harvesting 12 days after first shattering (H8) the germination percentage was slightly reduced after 240 days of storage.

The immature seeds as recorded in H1 (25% of pods in yellow colour) or H2 (50% of pods in yellow colour) stages recorded low germination from the beginning itself as compared to other stages of harvesting. The same seeds even after 240 days of storage, have shown significant decline in lab germination. Likewise delayed harvestings after 12 days from the first shattering also has shown decline in lab germination.

Table 4.14 d. Lab germination (per cent) in soybean variety Hardee as influenced by harvesting stages during storage period (Jan to Aug 1991)

Treatments	Storage period (days)								
	0	30	60	90	120	150	180	210	240
Harvesting stages									
H1 (25% pods/plant in yellow colour)	76.5	76.25	75.0	73.2	69.2	66.2	62.0	57.0	52.0
H2 (50% pods/plant in yellow colour)	87.5	87.0	86.0	84.2	82.2	80.0	77.0	73.0	69.2
H3 (75% pods/plant in yellow colour)	99.0	99.0	98.0	98.0	97.2	97.0	96.0	95.0	94.0
H4 (Beginning of shattering)	99.0	99.0	98.0	98.0	97.0	96.0	95.0	94.0	92.0
H5 (3 days after Ist shattering)	99.0	99.0	98.0	97.0	96.0	95.0	94.0	93.0	91.0
H6 (6 days after Ist shattering)	98.0	98.0	97.0	97.0	96.0	95.0	94.0	92.0	91.0
H7 (9 days after Ist shattering)	98.0	98.0	97.0	96.0	95.0	94.0	93.0	91.0	90.0
H8(12 days after Ist shattering)	98.0	98.0	97.0	96.0	95.0	93.0	92.0	90.0	89.0
Mean	94.3	94.2	93.2	92.4	90.9	89.5	97.8	85.5	83.5
F-test	*	*	*	*	*	*	*	*	*
S.Em. ±	0.39	0.41	0.53	0.47	0.61	0.69	0.63	0.63	0.55
C.D. at 5%	1.15	1.18	1.55	1.37	1.78	2.04	1.84	1.84	1.58
C.V. %	0.84	0.86	1.14	1.02	1.34	1.56	1.42	1.46	1.22

Table 4.14 e. Lab germination (per cent) in soybean variety KHSb2 as influenced by harvesting stages during storage period (Jan to Aug 1991)

Treatments	Storage period (days)									
	0	30	60	90	120	150	180	210	240	
Harvesting stages										
H1 (25% pods/plant in yellow colour)	75.5	74.2	73.2	71.0	68.2	65.0	61.2	57.0	51.5	
H2 (50% pods/plant in yellow colour)	86.5	86.2	85.0	83.5	80.0	77.5	74.2	76.0	71.2	
H3 (75% pods/plant in yellow colour)	98.5	98.2	98.0	97.0	97.0	96.0	95.0	90.0	93.0	
H4 (Beginning of shattering)	98.0	98.0	97.0	97.0	96.0	95.0	94.0	93.0	92.0	
H5 (3 days after Ist shattering)	98.0	98.0	97.0	97.0	96.0	95.0	94.0	93.0	92.0	
H6 (6 days after Ist shattering)	98.0	98.0	97.0	96.0	96.0	95.0	94.0	93.0	92.0	
H7 (9 days after Ist shattering)	97.0	97.0	96.0	96.0	95.0	94.0	93.0	92.0	90.0	
H8(12 days after Ist shattering)	97.0	97.0	96.0	96.0	95.0	94.0	92.0	90.0	88.0	
Mean	93.5	93.3	92.4	91.6	90.4	88.9	87.1	86.0	83.8	
F-test	*	*	*	*	*	*	*	*	*	*
S.Em.±	0.43	0.54	0.64	0.68	0.63	0.34	0.62	1.52	1.48	
C.D. at 5%	1.27	0.66	1.88	1.99	1.85	1.26	1.83	1.52	0.85	
C.V. %	0.93	1.17	1.40	1.49	1.40	1.91	1.42	1.21	0.67	

4.3.2 Field emergence behaviour in storage:

The data on field emergence of different varieties as influenced by harvesting stages during the storage period of eight months are presented in Tables 4.15a, 4.15b, 4.15c, 4.15d and 4.15e, respectively.

(a) Due to varieties:

The field emergence progressively decreased in all varieties in storage from 0 to 240 days. It decreased from 92.1 to 77.5 per cent in Monetta, from 92.7 to 80.08 per cent in PK 471, from 92.54 to 79.4 per cent in Bragg, from 92.3 to 78.2 per cent in Hardee and from 92.3 to 78.8 per cent in KHSb2.

(b) Due to harvesting stages:

The field emergence both in the beginning and at the end was fairly high and satisfactory and it was well above 85 per cent in H3 (harvesting when 75% of pods in yellow colour), in H4 (the beginning of shattering), in 3 days (H5), 6 days (H6) and 9 days (H7) after first shattering. In 12 days after first shattering (H8) the field emergence percentage was slightly reduced after 240 days of storage.

The immature seeds as recorded in H1 (25% of pods in yellow colour) or H2 (50% of pods in yellow colour) stages

Table 4.15 a. Field emergence (per cent) in soybean variety Monetta as influenced by harvesting stages during storage period (Jan to Aug 1991)

Treatments	Storage period (days)								
	0	30	60	90	120	150	180	210	240
Harvesting stages									
H1 (25% pods/plant in yellow colour)	70.4	70.0	69.0	67.0	65.0	62.0	58.0	53.0	47.4
H2 (50% pods/plant in yellow colour)	84.0	83.0	82.0	81.0	79.4	77.0	75.0	71.7	66.0
H3 (75% pods/plant in yellow colour)	97.7	97.0	97.4	96.0	96.0	95.0	95.0	92.0	88.4
H4 (Beginning of shattering)	97.4	97.0	97.0	96.0	95.0	94.0	93.0	90.0	86.4
H5 (3 days after 1st shattering)	97.0	97.0	97.0	96.0	95.0	93.0	92.0	90.0	86.0
H6 (6 days after 1st shattering)	97.4	97.0	97.0	96.0	94.0	92.0	91.0	83.4	85.0
H7 (9 days after 1st shattering)	97.4	97.0	96.4	94.0	93.3	91.0	90.0	88.0	85.0
H8 (12 days after 1st shattering)	96.0	96.0	95.0	93.0	92.0	90.0	89.0	87.0	82.0
Mean	92.1	91.7	91.0	89.7	88.5	87.7	86.2	82.5	77.3
F-test	*	*	*	*	*	*	*	*	*
S.Em. ±	0.40	0.43	0.56	0.66	0.66	0.66	0.39	0.44	0.49
C.D. at 5%	1.21	1.34	0.68	1.99	0.99	1.21	1.34	1.51	
C.V. %	0.74	0.83	1.04	1.29	1.29	1.28	0.81	0.92	1.09

Table 4.15 b. Field emergence (per cent) in soybean variety PK47las influenced by harvesting stages during storage period (Jan to Aug 1991)

Treatments	Storage period (days)								
	0	30	60	90	120	150	180	210	240
Harvesting stages									
H1 (25% pods/plant in yellow colour)	76.7	70.4	69.0	68.0	66.4	64.0	61.4	57.0	50.4
H2 (50% pods/plant in yellow colour)	82.4	82.4	81.0	80.0	78.0	76.4	74.0	72.4	67.4
H3 (75% pods/plant in yellow colour)	98.4	98.4	98.4	97.0	96.0	95.0	95.0	93.0	91.0
H4 (Beginning of shattering)	98.4	98.4	97.0	96.0	95.0	94.0	94.0	91.0	89.0
H5 (3 days after 1st shattering)	97.4	97.0	96.0	96.0	95.0	93.0	92.0	89.0	88.0
H6 (6 days after 1st shattering)	97.0	97.0	96.0	95.0	93.0	91.0	90.0	88.0	86.0
H7 (9 days after 1st shattering)	96.0	96.0	95.0	94.0	92.0	90.0	89.0	87.0	86.0
H8 (12 days after 1st shattering)	96.0	96.0	95.0	93.0	91.0	89.0	88.0	86.0	84.0
Mean	92.7	91.91	90.91	89.87	88.29	86.54	85.45	82.91	80.08
F-test	*	*	*	*	*	*	*	*	*
S.Em.+	0.38	0.37	0.51	0.61	0.48	0.43	0.46	0.46	0.42
C.D. at 5%	1.16	1.11	1.54	1.83	1.45	1.31	1.39	1.39	1.27
C.V. %	0.72	0.69	0.97	1.17	0.95	0.87	0.93	0.96	0.89

Table 4.15 c. Field emergence (per cent) in soybean variety Bragg as influenced by harvesting stages during storage period (Jan to Aug 1991)

Treatments	Storage period (days)								
	0	30	60	90	120	150	180	210	240
Harvesting stages									
H1 (25% pods/plant in yellow colour)	71.4	71.0	70.0	68.0	66.0	64.0	61.0	55.4	49.4
H2 (50% pods/plant in yellow colour)	83.0	83.0	82.0	81.0	80.4	78.0	76.0	73.0	69.0
H3 (75% pods/plant in yellow colour)	98.0	98.4	98.0	97.0	97.0	96.0	95.0	93.4	91.0
H4 (Beginning of shattering)	98.4	98.4	97.0	97.0	96.0	95.0	94.0	92.0	89.0
H5 (3 days after 1st shattering)	98.4	98.0	97.0	96.4	96.4	94.0	93.0	90.0	87.0
H6 (6 days after 1st shattering)	97.0	97.0	96.0	95.0	94.0	93.0	92.0	89.0	86.0
H7 (9 days after 1st shattering)	97.0	97.0	95.0	95.0	95.0	94.0	92.0	91.0	89.0
H8(12 days after 1st shattering)	97.0	97.0	94.0	93.4	92.0	91.0	90.0	88.0	84.0
Mean	92.54	92.4	91.1	89.5	89.4	87.8	86.5	83.7	79.2
F-test	*	*	*	*	*	*	*	*	*
S.Em.+	0.42	0.52	0.52	0.36	0.47	0.49	0.52	0.53	0.54
C.D. at 5%	1.29	1.58	1.58	1.08	1.43	1.49	1.56	0.61	1.63
C.V. %	0.79	0.98	0.99	0.68	0.91	0.97	1.03	1.09	1.16

Table 4.15 d. Field emergence (per cent) in soybean variety Hardee as influenced by harvesting stages during storage period (Jan to Aug 1991)

Treatments	Storage period (days)								
	0	30	60	90	120	150	180	210	240
Harvesting stages									
H1 (25% pods/plant in yellow colour)	73.4	73.0	72.0	71.0	67.0	63.4	58.0	52.0	44.4
H2 (50% pods/plant in yellow colour)	84.7	84.0	83.0	82.0	81.0	79.4	76.4	71.4	67.0
H3 (75% pods/plant in yellow colour)	97.4	97.4	97.0	86.4	96.0	95.0	94.0	93.0	90.8
H4 (Beginning of shattering)	97.4	97.0	96.0	95.0	94.0	93.0	93.0	91.0	89.0
H5 (3 days after 1st shattering)	97.0	97.0	96.0	94.0	93.0	92.0	91.0	90.0	88.0
H6 (6 days after 1st shattering)	97.0	97.0	96.0	94.0	92.0	90.0	89.0	87.0	85.0
H7 (9 days after 1st shattering)	95.4	95.0	94.0	93.0	92.0	90.0	89.0	87.0	85.0
H8 (12 days after 1st shattering)	95.0	95.0	94.0	92.0	91.0	89.0	88.0	86.0	83.0
Mean	92.2	91.8	91.0	88.4	88.2	86.5	85.0	82.3	78.3
F-test	*	*	*	*	*	*	*	*	*
S.Em. ±	0.45	0.39	0.42	0.38	0.55	0.49	0.56	0.33	0.29
C.D. at 5%	1.36	1.21	1.27	1.15	1.65	1.49	1.69	0.98	0.89
C.V. %	0.85	0.75	0.79	0.73	1.07	0.98	1.13	0.66	0.63

Table 4.15 e. Field emergence (per cent) in soybean variety KHSb2 as influenced by harvesting stages during storage period (Jan to Aug 1991)

Treatments	Storage period (days)								
	0	30	60	90	120	150	180	210	240
Harvesting stages									
H1 (25% pods/plant in yellow colour)	73.0	72.0	71.0	69.0	66.0	62.33	57.00	51.4	44.00
H2 (50% pods/plant in yellow colour)	84.4	84.0	83.0	81.0	79.0	76.0	72.0	68.0	62.0
H3 (75% pods/plant in yellow colour)	97.7	97.4	97.0	96.0	96.0	95.0	94.0	93.0	91.0
H4 (Beginning of shattering)	97.4	97.0	96.0	95.0	95.0	94.0	93.0	91.0	89.0
H5 (3 days after 1st shattering)	97.0	97.0	96.0	95.0	94.0	93.0	92.0	90.0	88.0
H6 (6 days after 1st shattering)	97.0	96.0	95.0	94.0	93.0	92.0	91.0	89.0	88.8
H7 (9 days after 1st shattering)	96.0	96.0	95.0	94.0	93.0	92.0	91.0	89.0	87.8
H8 (12 days after 1st shattering)	96.0	96.0	93.0	91.0	89.0	87.0	86.0	84.0	82.0
Mean	92.3	91.8	90.7	89.4	88.3	86.6	84.3	81.0	78.8
F-test	*	*	*	*	*	*	*	*	*
S.Em. +	0.52	0.61	0.36	0.42	0.42	0.31	1.09	0.39	0.47
C.D. at 5%	1.58	0.83	0.07	1.27	0.25	0.93	3.33	1.16	1.41
C.V. %	0.98	1.34	0.68	1.81	0.91	0.61	2.32	0.79	0.99

recorded low field emergence from the beginning itself compared to other stages of harvesting. The same seeds even after 240 days of storage, have shown significant decline in field emergence. Likewise delayed harvestings after 12 days from the first shattering also has shown decline in field emergence.

4.3.3 Vigour index(mean dry weight of seedling X germination percentage as influenced by harvesting stages and storage period

The data on vigour index of different varieties as influenced by harvesting stages during the storage period of eight months are presented in Tables 4.16a, 4.16b, 4.16c, 4.16d, and 4.16d, respectively.

(a) Due to varieties:

Vigour index of different varieties differed significantly as influenced by harvesting stages during the storage period. The vigour index progressively decreased in all varieties in storage from 0 to 240 days. It decreased from 4.36 to 3.73 in Monetta, from 4.33 to 3.76 in PK 471, from 4.40 to 3.79 in Bragg, from 4.38 to 3.76 in Hardee and from 4.37 to 3.87 in KHSb2.

(b) Due to harvesting stages:

Irrespective of varieties, the vigour index in the

Table 4.16 a. Vigour index (mean dry weight of seedling X germination percentage) in soybean variety Monetta as influenced by harvesting stages during storage period (Jan to Aug 1991)

Treatments	Storage period (days)								
	0	30	60	90	120	150	180	210	240
Harvesting stages									
H1 (25% pods/plant in yellow colour)	3.44	3.46	3.43	3.39	3.31	2.99	2.87	2.69	2.47
H2 (50% pods/plant in yellow colour)	4.27	4.25	4.23	4.17	4.13	3.57	3.41	3.33	3.14
H3 (75% pods/plant in yellow colour)	4.65	4.66	4.66	4.68	4.62	4.49	4.43	4.27	4.12
H4 (Beginning of shattering)	4.63	4.53	4.66	4.57	4.17	4.38	4.29	4.21	4.15
H5 (3 days after 1st shattering)	4.56	4.46	4.45	4.43	4.34	4.31	4.23	4.18	4.06
H6 (6 days after 1st shattering)	4.45	4.42	4.44	4.41	4.32	4.28	4.21	4.17	4.02
H7 (9 days after 1st shattering)	4.44	4.41	4.39	4.34	4.31	4.29	4.21	4.05	3.94
H8 (12 days after 1st shattering)	4.41	4.40	4.38	4.31	4.30	4.26	4.18	4.04	3.91
Mean	4.36	4.32	4.31	4.30	4.22	4.07	3.99	3.89	3.73
F-test	*	*	*	*	*	*	*	*	*
S.Em.+	0.78	0.15	0.48	0.42	0.41	0.44	0.32	0.28	0.29
C.D. at 5%	0.22	0.15	0.14	0.12	0.12	0.12	0.94	0.83	0.87
C.V. %	3.60	2.48	2.26	1.89	2.01	2.00	1.62	1.48	1.59

Table 4.16 b. Vigour index (mean dry weight of seedling x germination percentage) in soybean variety PK 471 as influenced by harvesting stages during storage period (Jan to Aug 1991)

Treatments	Storage period (days)								
	0	30	60	90	120	150	180	210	240
Harvesting stages									
H1 (25% pods/plant in yellow colour)	3.44	3.27	3.26	3.19	3.13	2.99	2.87	2.71	2.53
H2 (50% pods/plant in yellow colour)	4.02	4.25	4.23	4.17	4.14	3.56	3.51	3.32	3.17
H3 (75% pods/plant in yellow colour)	4.65	4.63	4.66	4.68	4.62	4.49	4.43	4.31	4.20
H4 (Beginning of shattering)	4.63	4.46	4.45	4.40	4.40	4.33	4.29	4.21	4.17
H5 (3 days after 1st shattering)	4.56	4.46	4.44	4.43	4.35	4.27	4.23	4.18	4.09
H6 (6 days after 1st shattering)	4.45	4.42	4.43	4.41	4.29	4.23	4.22	4.17	4.05
H7 (9 days after 1st shattering)	4.45	4.41	4.39	4.36	4.28	4.23	4.21	4.05	3.97
H8 (12 days after 1st shattering)	4.43	4.31	4.29	4.29	4.24	4.20	4.19	4.05	3.93
Mean	4.33	4.33	4.26	4.22	4.18	4.03	3.99	3.80	3.76
F-test	*	*	*	*	*	*	*	*	*
S.Em. ±	0.11	0.59	0.52	0.12	0.41	0.37	0.32	0.13	0.20
C.D. at 5%	0.30	0.17	0.15	0.33	0.12	0.10	0.95	0.38	0.58
C.V. %	4.82	2.75	2.42	5.22	1.98	1.82	1.63	3.78	1.06

Table 4.16 c. Vigour index (mean dry weight of seedling X germination percentage) in soybean variety Bragg as influenced by harvesting stages during storage period (Jan to Aug 1991)

Treatments	Storage period (days)								
	0	30	60	90	120	150	180	210	240
Harvesting stages									
H1 (25% pods/plant in yellow colour)	3.49	3.46	3.42	3.40	3.39	2.86	2.82	2.73	2.51
H2 (50% pods/plant in yellow colour)	4.31	4.31	4.23	4.21	4.16	3.69	3.63	3.79	3.21
H3 (75% pods/plant in yellow colour)	4.71	4.72	4.71	4.71	4.68	4.41	4.41	4.34	4.31
H4 (Beginning of shattering)	4.66	4.57	4.67	4.61	4.43	4.39	4.35	4.25	4.19
H5 (3 days after 1st shattering)	4.58	4.49	4.53	4.45	4.41	4.37	4.32	4.23	4.12
H6 (6 days after 1st shattering)	4.50	4.48	4.47	4.45	4.39	4.36	4.29	4.23	4.98
H7 (9 days after 1st shattering)	4.47	4.47	4.44	4.45	4.37	4.34	4.27	4.18	4.05
H8(12 days after 1st shattering)	4.46	4.44	4.43	4.39	4.34	4.31	4.25	4.01	3.92
Mean	4.40	4.37	4.36	4.33	4.27	4.09	4.04	3.97	3.74
F-test	*	*	*	*	*	*	*	*	*
S.E.m. _t	0.57	0.38	0.45	0.36	0.34	0.34	0.25	0.12	0.48
C.D. at 5%	0.16	0.12	0.13	0.10	0.11	0.10	0.74	0.37	0.14
C.V. %	2.61	1.75	2.09	1.67	1.52	1.58	1.25	3.47	2.53

Table 4.16 d. Vigour index (mean dry weight of seedling X germination percentage) in soybean variety Hardee as influenced by harvesting stages during storage period (Jan to Aug 1991)

Treatments	Storage period (days)								
	0	30	60	90	120	150	180	210	240
Harvesting stages									
H1 (25% pods/plant in yellow colour)	3.43	3.41	3.39	3.31	3.31	3.02	2.89	2.72	2.43
H2 (50% pods/plant in yellow colour)	4.31	4.29	4.27	4.19	4.17	3.59	3.51	3.37	3.23
H3 (75% pods/plant in yellow colour)	4.68	4.67	4.63	4.59	4.55	4.52	4.47	4.34	4.18
H4 (Beginning of shattering)	4.65	4.65	4.51	4.50	4.39	4.37	4.32	4.22	4.13
H5 (3 days after 1st shattering)	4.61	4.47	4.46	4.44	4.38	4.36	4.25	4.22	4.04
H6 (6 days after 1st shattering)	4.48	4.43	4.44	4.42	4.38	4.35	4.25	4.20	4.05
H7 (9 days after 1st shattering)	4.46	4.43	4.43	4.42	4.32	4.35	4.24	4.06	3.97
H8 (12 days after 1st shattering)	4.42	4.41	4.42	4.36	4.35	4.32	4.16	4.06	3.91
Mean	4.38	4.34	4.31	4.29	4.23	4.04	4.01	3.89	3.76
F-test	*	*	*	*	*	*	*	*	*
S.Em.+	0.63	0.51	0.57	0.34	0.39	0.26	0.25	0.32	0.24
C.D. at 5%	0.18	0.49	0.17	0.11	0.85	0.77	0.74	0.93	0.72
C.V. ‡	2.88	2.35	2.49	1.59	1.38	1.23	1.31	1.27	1.76

Table 4.16 e. Vigour index (mean dry weight of seedling X germination percentage) in soybean variety KHSb2 as influenced by harvesting stages during storage period (Jan to Aug 1991)

Treatments	Storage period (days)									
	0	30	60	90	120	150	180	210	240	
Harvesting stages										
H1 (25% pods/plant in yellow colour)	3.45	3.44	3.39	3.32	3.32	3.07	2.08	2.71	3.51	
H2 (50% pods/plant in yellow colour)	4.28	4.26	4.22	4.18	4.17	3.62	3.51	3.40	3.17	
H3 (75% pods/plant in yellow colour)	4.68	4.69	4.68	4.64	4.65	4.52	4.48	4.32	4.17	
H4 (Beginning of shattering)	4.64	4.56	4.56	4.52	4.39	4.39	4.31	4.24	4.16	
H5 (3 days after 1st shattering)	4.55	4.52	4.52	4.49	4.37	4.33	4.28	4.21	4.03	
H6 (6 days after 1st shattering)	4.47	4.47	4.46	4.45	4.35	4.33	4.28	4.21	4.03	
H7 (9 days after 1st shattering)	4.45	4.43	4.43	4.42	4.34	4.32	4.24	4.15	3.96	
H8 (12 days after 1st shattering)	4.44	4.47	4.41	4.39	4.38	4.30	4.03	4.05	3.92	
Mean	4.37	4.35	4.34	4.31	4.25	4.12	4.04	3.91	3.87	
F-test	*	*	*	*	*	*	*	*	*	*
S.E.m. _t	0.46	0.31	0.28	0.34	0.24	0.38	0.28	0.53	0.30	
C.D. at 5%	0.13	0.87	0.83	0.94	0.86	0.12	0.84	0.61	0.87	
C.V. %	2.13	1.37	1.28	1.43	1.34	1.84	1.43	2.62	1.61	

beginning and after 240 days of storage was significantly the lowest in H1 and H2. The vigour index both in the beginning and at the end was fairly high and satisfactory and it was well above 3.94 in H3 (harvesting when 75% of pods in yellow colour), in H4 (the beginning of shattering), in 3 days (H5), 6 days (H6) and 9 days (H7) after first shattering. In 12 days after first shattering (H8) the vigour index was slightly reduced after 240 days of storage.

The immature seeds as recorded in H1 (25% of pods in yellow colour) or H2 (50% of pods in yellow colour) stages recorded low vigour index from the beginning itself as compared to other stages of harvesting. The same seeds even after 240 days of storage, have shown significant decline in vigour index. Likewise delayed harvestings by 12 days from the first shattering also have shown decline in vigour index.

4.3.4 Electrical conductivity

The data on E.C of different varieties as influenced by harvesting stages during the storage period are presented in Tables 17a, 17b, 17c, 17d and 17e, respectively.

(a) Due to varieties:

The E.C. of seeds of different varieties differed significantly as influenced by harvesting stages during the

Table 4.17a. Electrical conductivity (micro mhos/cm) in soybean variety Monetta as influenced by harvesting stages during storage period (Jan to Aug 1991)

Treatments	Storage period (days)				
	0	60	120	180	240
Harvesting stages					
H1 (25% pods/plant in yellow colour)	895	1205.5	1453.5	1619.0	1812.0
H2 (50% pods/plant in yellow colour)	686	1050.0	1241.5	1438.0	1618.5
H3 (75% pods/plant in yellow colour)	489	540.0	851.5	896.0	1141.5
H4 (Beginning of shattering)	490	593.5	916.0	987.0	1249.5
H5 (3 days after 1st shattering)	490	617.0	985.5	1091.0	1262.0
H6 (6 days after 1st shattering)	492	620.5	988.0	1127.0	1271.5
H7 (9 days after 1st shattering)	495	624.0	989.5	1133.5	1373.5
H8 (12 days after 1st shattering)	498	625.0	995.5	1160.0	1378.5
Mean	567.1	734.4	1052.6	1120.6	1393.3
F-test	*	*	*	*	*
S.Em. \pm	9.70	26.01	18.89	52.22	18.84
C.D. at 5%	27.31	84.84	61.60	170.31	61.44
C.V. %	7.38	5.00	2.53	6.25	1.95

Table 4.17b. Electrical conductivity (micro mhos/cm) in soybean variety PK 471 as influenced by harvesting stages during storages period (Jan to Aug 1991)

Treatments	Storage period (days)				
	0	60	120	180	240
Harvesting stages					
H1 (25% pods/plant in yellow colour)	824	1167.0	1376.5	1567.0	1940.0
H2 (50% pods/plant in yellow colour)	662	965.5	1209.0	1414.5	1740.0
H3 (75% pods/plant in yellow colour)	460	549.5	911.5	981.0	1087.0
H4 (Beginning of shattering)	472	558.0	932.0	990.0	1245.0
H5 (3 days after 1st shattering)	483	567.0	935.0	991.5	1256.0
H6 (6 days after 1st shattering)	486	571.0	942.0	1003.5	1359.5
H7 (9 days after 1st shattering)	487	584.0	978.5	1006.5	1362.0
H8 (12 days after 1st shattering)	489	582.0	1102.0	1013.0	1483.5
Mean	545	693.06	1055.8	1567.0	1433.0
F-test	*	*	*	*	*
S.Em. †	43.37	26.02	14.30	21.33	20.15
C.D. at 5%	141.44	84.36	46.65	69.57	65.72
C.V. ‡	11.24	5.31	1.73	2.69	2.05

Table 4.17c. Electrical conductivity (micro mhos/cm) in soybean variety Bragg as influenced by harvesting stages during storages period (Jan to Aug 1991)

Treatments	Storage period (days)				
	0	60	120	180	240
Harvesting stages					
H1 (25% pods/plant in yellow colour)	695	1043.5	1388.5	1732.5	1947.5
H2 (50% pods/plant in yellow colour)	615	671.5	1219.0	1525.0	1749.5
H3 (75% pods/plant in yellow colour)	461	544.5	916.5	992.0	1241.5
H4 (Beginning of shattering)	475	593.5	941.5	1033.5	1268.0
H5 (3 days after 1st shattering)	481	601.0	959.0	1046.5	1268.0
H6 (6 days after 1st shattering)	482	601.5	965.0	1055.5	1278.5
H7 (9 days after 1st shattering)	482	602.0	973.0	1060.5	1287.0
H8(12 days after 1st shattering)	483	604.5	986.0	1066.5	1388.0
Mean	521.9	695.1	1043.6	1189.0	1442.5
F-test	*	*	*	*	*
S.Em.+	61.02	20.03	6.38	21.08	20.83
C.D. at 5%	199.00	65.35	22.44	68.76	67.95
C.V. %	16.53	4.07	0.93	2.50	2.08

Table 4.17d. Electrical conductivity (micro mhos/cm) in soybean variety Hardee as influenced by harvesting stages during storages period (Jan to Aug 1991)

Treatments	Storage period (days)				
	0	60	120	180	240
Harvesting stages					
H1 (25% pods/plant in yellow colour)	722	1154.5	1444.5	1640.0	2007.5
H2 (50% pods/plant in yellow colour)	666	977.0	1241.0	1562.5	1871.5
H3 (75% pods/plant in yellow colour)	444	590.5	896.5	1053.0	1204.5
H4 (Beginning of shattering)	481	593.5	923.0	1095.0	1253.0
H5 (3 days after 1st shattering)	481	599.5	929.5	1101.5	1263.0
H6 (6 days after 1st shattering)	482	602.5	936.5	1153.5	1276.5
H7 (9 days after 1st shattering)	485	603.0	961.5	1173.0	1383.0
H8 (12 days after 1st shattering)	512	608.0	976.5	1180.0	1389.0
Mean	534.4	716.0	1038.6	1244.8	1455.0
F-test	*	*	*	*	*
S.Em. ±	23.40	20.42	11.51	36.17	20.42
C.D. at 5%	76.31	66.60	37.55	117.96	66.59
C.V. %	6.19	4.03	1.56	4.10	2.01

Table 4.17e. Electrical conductivity (micro mhos/cm) in soybean variety KHSb2 as influenced by harvesting stages during storages period (Jan to Aug 1991)

Treatments	Storage period (days)				
	0	60	120	180	240
Harvesting stages					
H1 (25% pods/plant in yellow colour)	712	923.0	1162.0	1440.0	1874.0
H2 (50% pods/plant in yellow colour)	637	841.0	1009.5	1359.0	1756.5
H3 (75% pods/plant in yellow colour)	438	551.0	834.0	929.0	1116.0
H4 (Beginning of shattering)	482	555.5	889.5	940.0	1243.5
H5 (3 days after 1st shattering)	484	600.5	908.0	979.0	1267.0
H6 (6 days after 1st shattering)	484	596.5	925.0	1033.0	1269.5
H7 (9 days after 1st shattering)	486	605.0	987.5	1060.0	1371.0
H8(12 days after 1st shattering)	493	606.0	989.0	1145.0	1458.0
Mean	527.2	659.8	963.0	1097.87	1470.5
F-test	*	*	*	*	*
S.Em. \pm	23.05	25.13	7.70	22.83	96.36
C.D. at 5%	77.13	81.97	25.14	74.47	314.25
C.V. %	6.34	5.38	1.13	2.96	9.60

storage. The E.C. of seeds progressively increased in all varieties in storage from 0 to 240 days. It increased from 567.1 to 1393.3 m.mhos/cm in Monetta, from 545 to 1433.0 m.mhos/cm in PK 471, from 521 to 1442.5 m. mhos/cm in Bragg, from 5344.4 to 1455 m.mhos/cm in Hardee and from 527.2 to 1470.5 umhos/cm in KHSb2.

(b) Due to harvesting stages:

The E.C of seeds both in the beginning and at the end was very stable and it was well below 1389 m. mhos/cm in H3 harvesting (when 75% of pods in yellow colour), in H4 (the beginning of shattering) in 3 days (H5), 6 days (H6), 9 days (H7) after first shattering. Only in 12 days (H8) after first shattering the E.C of seed was slightly increased after 240 days of storage.

The immature seeds as recorded in H1 (25% of pods in yellow colour) or H2 (50% of pods in yellow colour) stages recorded high E.C. from the beginning itself as compared to other stages of harvesting. The same seeds even after 240 days of storage, have shown significant increases in electrical conductivity. Likewise delayed harvesting by 12 days from the first shattering also have shown increased in electrical conductivity.

DISCUSSION

V DISCUSSION

The results on seed development, maturation, storability and seed quality in five varieties of soybean are discussed in this chapter.

5.1 Studies on Pod and Seed Development in Soybean Varieties

Soybean varieties differed significantly in their duration taken to 50 per cent flowering (33 to 43 days) and physiological maturity (79 to 93 days). The duration for pod development also ranged from (46 to 50 days) from flowering.

The dry weight of seeds was the lowest (0.12g/10 pods) after 15 days from flowering and it progressively increased and reached its peak (3.68 g/10 pods) 48 days after flowering and finally on 52nd day after flowering it was 3.22 g/10 pods. Varieties differed in their dry matter accumulation in seeds. Hardee recorded the highest dry weight of seeds (0.16 to 4.59 g/10 pods) followed by Bragg (0.13 to 4.24 g/10 pods), PK 471 (0.12 to 3.99 g/10 pods), KHSb2 (0.11 to 3.06 g/10 pods) and Monetta (0.10 to 2.86 g/10 pods). Maximum dry weight was recorded in Hardee in about 46 to 50 days after flowering (4.66 g/10 pods). Bragg recorded the maximum dry weight 46 to 50 days after flowering (4.24 g/10 pods). PK 471 (3.99 g/10 pods), KHSb2

(4.66 g/10 pods) and Monetta (2.86 g/10 pods) recorded the maximum dry weight 46 to 50 days after flowering. Thus the dry weight of seed (g/10 pods) of all five varieties was attained 44 to 48 days after flowering.

The dry weight of husk also progressively increased from 0.80 g/10 pods on 15th day from flowering and reached its peak 1.58 g/10 pods on 46th day from flowering and subsequently the husk weight progressively decreased to 1.33 g/10 pods 52 days from flowering.

Varieties also differed in the dry matter accumulation of husk. The husk weight reached its peak on 40th day in Monetta, on 46th day in case of PK 471 and Bragg. The husk weight of Hardee and KHSb2 reached its peak on 42th day. In all these varieties, the husk weight progressively increased and reached its peak and subsequently it slightly declined at 52nd day.

The moisture per cent both in the husk (81.47 to 16.97%) and seed (85.75 to 26.37%) progressively decreased with progressive development of pod from 15th to 52nd day. The moisture percentage of seed on 44th day (53.85%), 46th day (48.46%) and 48 day (44.46%) from flowering ranged from 53.85 to 44.50 per cent which coincided with the maximum dry matter accumulation in the seeds in most of the varieties.

The moisture percentage in husk also progressively decreased from 81.47% on 15th day to 16.97% on 52nd day after flowering. The moisture percentage in the husk decreased from 54.54 to 43.57 per cent. The moisture content in the husk was less (81.47%) in the beginning as compared to that of seeds (85.75%) and after 52nd day from flowering, the moisture percentage in the husk decreased drastically at a faster rate to 16.97 per cent while in seeds rate of decrease was lower (26.37%) on 52nd day from flowering.

The developing seeds gave 11.75 per cent of germination even after 15th day of flowering and the germination percentage of developing seeds progressively increased and reached its peak by 50th day (99.55%) and on 52nd day it remained almost constant (99.45%).

The developing seeds gave maximum germination after 46th day from flowering in Monetta (99.50%), after 48th day from flowering in Hardee (99.50%), after 48th day from flowering in Bragg (100%) and 50th day from flowering in KHSb2 (100%) and the same range of germination was maintained in all varieties upto 50th day from flowering.

The dry matter distribution in the husk (per cent to total) was the highest in the beginning and with advance in age it decreased. In Monetta it was 86.84 per cent in the beginning and at 52nd day it reduced to 27.91 per cent. In

PK 471, it was from 81.71 to 25.88 per cent. In Bragg it decreased from 87.69 to 28.33 per cent. In Hardee, it was from 88.24 per cent to 28.02 per cent. In KHSb2 it was from 86.03 to 28.15 per cent.

The dry matter distribution in the seed in all varieties progressively increased with advance in age. In Monetta the dry matter distribution into the seed was 13.11 to 72.08 per cent. In PK 471 it was from 18.29 to 74.12 per cent. In Bragg it was from 12.31 to 72.77 per cent. In Hardee it was from 11.66 to 71.98 per cent. In KHSb2 it was increased from 13.97 to 71.84 per cent.

The vigour index (mean length of seedling x germination per cent) of developing seeds was initially the lowest on 15th day (248) and reached its peak on 48th day (3192). The developing seeds of varieties also differed in their vigour index. Maximum vigour index was attained in Monetta (3081) on 46th day, PK 471 on 48th day (2998) followed by Bragg (3125), whereas Hardee (3084) and KHSb2 (3165) on 50th day and also the vigour index (mean dry weight of seedling x germination per cent) of developing seeds was initially the lowest on 15th day (0.43) and reached its peak on 48th day (4.99). The developing seeds of varieties also differed in their vigour index. Maximum vigour index was attained in Monetta on 46th day (4.74). both PK 471 (4.48) and Bragg

(5.52) on 48th day, whereas Hardee (5.56) and (5.06) on 48th day from flowering.

Thus the soybean varieties reached their maximum seed weight (2.86 to 4.59 g/10 pods) after about 46th to 48th day from flowering. Likewise the moisture content in the seeds ranged from 32.15 to 48.49 per cent. The percentage of dry matter distribution into husk ranged from 30.57 to 27.44 per cent, and in seed it ranged from 69.43 to 72.56 per cent and also germination percentage ranged from 99.50 to 100 per cent.

The vigour index of (mean length of seedling x germination percentage) also ranged from 2998 to 3125 among the varieties during maturity and also in vigour index of (mean dry weight of seedling and germination percentage) also ranged from 4.64 to 4.99 among the varieties during maturity indicating the soybean varieties have recorded maximum dry weight in seeds with maximum germination and vigour index after 46 to 50 days from flowering or 79 to 93 days of total duration taken to attain physiological maturity.

At their respective physiological maturity all varieties have recorded maximum germination (99.50 to 100%) but have differed significantly in the dry weight of seeds (g/10 pods) (V4: 4.66 g; V3: 4.21g; V2: 3.94 g; V5: 3.06g; and V1:

2.86g), in moisture content of seeds (32.15% in V1, 41.81% in V4, 43.82% in V5, 48.49% in V4 and 50.21% in V3) and dry matter distribution in husk was the highest in V4 (30.54%) followed by V3 (30.07%), V4 (28.86%), V2 (28.22%) and lowest in V1 (29.35%). The dry matter distribution into seed was the highest in V2 (71.78%) and V5 (71.14%) followed by V1 (70.65%), V3 (69.93%) and V4 (69.42%). Likewise the vigour index (mean length of seedling X GM%) was the highest in V5 (3165) and V3 (3125) followed by V4 (3084), V1 (3081) and the lowest in V2 (2998). The vigour index as computed by the dry weight of seedling and GM% was also the highest in V4 (5.56) followed by V3 (5.52), V5 (5.28), V2 (4.98) and the lowest in V1 (4.74). The seed size in V4 was the largest followed by V3, V2 and others were small.

The dry weight of seeds progressively increased from 0.12 g on 15th day to 3.68 g/10 pods on 48th day and subsequently there was a slight decline (3.22 g/10 pods) on 52nd day, whereas the dry weight of husks (g/10 pods) increased progressively from (0.77 g/10 pods) and reached its peak on 46th day (1.59 g/10 pods) and subsequently it progressively decreased to 1.42 g/10 pods on 52nd day.

These results indicated that there is a progressive and fast dry matter accumulation in the developing seeds, whereas the dry matter accumulation in the husk after reaching

its peak progressively declined indicating that the dry matter accumulated in the husk might have migrated to the developing seeds which act as a potential sink in grain crops.

Similar observations have been made by several workers in soybean, pea, cowpea and Dolichos lablab. Burris (1973) reported that the germination percentage increased with increase in time after flowering although some varieties showed a reduction in germination between 30 and 40 days due to an increased percentage of hard seeds.

Jacinto et al. (1974) reported that the seeds after flowering at 8 days interval and studied for moisture content, size, dry weight, germination capacity and seedling vigour, when moisture content was relatively high (58%), the germination was low (65 %). High germination (98.4%) was obtained eight days before harvest.

Egli (1975) reported that the rate of accumulation of dry weight in seeds of soybean. He observed that the daily rate of seed dry matter accumulation ranged from 3.38 to 8.32 mg per seed in cultivar Amsoy-custer York. Significant differences were observed among the cultivars in the accumulation of dry matter.

Crookston and Hill (1979) also studied the physiological maturity of soybean seeds and found maximum dry weight

when seeds had an average of 58 per cent moisture content.

Tekrony et al. (1979) reported in soybean that the seed moisture content was 50 to 60 per cent at physiological maturity and it was 2 to 3 weeks before commercial harvest. Obendorf et al. (1980) also made the similar observation in soybean that seed moisture was about 55% at physiological maturity. Yoshida et al. (1983) showed that in determinate cultivar, seed formed from the last flowering group had slow dry matter accumulation with short effective seed filling period whereas in indeterminate cultivars seed from the last flowers had a short seed filling period.

Ortiz and Cianzio (1983) reported that seeds harvested 5 to 6 weeks after flowering would give higher germination and field stand.

Miles et al. (1988) reported that freshly harvested immature soybean seeds did not need desiccation period for the expression of maximum viability and normal seedling development. However, maximum germination did not occur until maximum accumulation of dry matter in seed. These are the observations made by different workers and they are in agreement with the present study.

5.2 Studies on the Effects of Harvesting Stages on Pod shattering and Seed Quality in Soybean Varieties

The field shattering of pods was studied in different varieties by harvesting them at different stages of maturity. There was no shattering in all the varieties when 25% (H1), 50% (H2) and 75% (H3) of the pods in each plant had turned yellow colour during maturation. However, the first shattering of pods (H4) began in all varieties after the pods and plant dried. On an average of all harvesting stages, pod shattering was the highest in Monetta (38%) followed by KHSb2 (16.2%), Hardee (14.4%) and it as the lowest in PK 471 (7.8%) and Bragg (4.0%). Monetta recorded the highest pod shattering (63.7%) when the crop was harvested 12 days after first shattering followed by KHSb2 (32%), Hardee (28%), PK 471 (12%) and Bragg (6%). Even after 12 days from first shattering, Bragg recorded the lowest shattering (3.98%) followed by PK 471 (12%). These results have indicated that Monetta, KHSb2 and Hardee are susceptible to shattering while Bragg and PK 471 were found fairly resistant to field shattering even after 12 days from first shattering or days from physiological maturity..

Among the harvesting stages, upto the stage of 75% of pods in each plant reached yellow colour, there was no shattering in all varieties. However, after the plants and pods dried up the pod shattering began in all the varieties.

The pod shattering increased from 5.1 to 28.4 per cent from first shattering to 12 days after first shattering. The pod shattering was 7.5, 16.2, 22.9 and 28.4 per cent, respectively from 3, 6, 9 and 12 days after first shattering.

These results have indicated the existence of varietal differences in field shattering of pods if harvesting is delayed.

Similar observations have been made by different workers in the case of soybean. Summers ^{C. et al. 1987} et al. (1986) reported that the in situ wetting of soybean pods prior to harvesting was used as a means of reducing soybean seed shattering loss. In situ wetting slightly decreased the shatter loss. Tsuchiya (1987) reported that the pod shattering was influenced by the presence of fibrous tissue in the jointing region, environment, pod moisture content and varietal characteristics. Pod shattering of more than 78% is considered as susceptible to shattering and less than 10 per cent as a resistance. Philbrook and Oplinger (1989) observed that the average soybean field losses were 10 per cent of potential yield. Field loss was 6.1 per cent at harvest maturity and it increased to 13.9 per cent at 42 days after maturity. Delayed harvesting lead to reduction in net yield of 11 kg/ha/day. The observations in this study on field shattering are in agreement with other workers.

5.3 Studies on the Effects of Harvesting Stages on the Storability of Soybean Seeds

The seeds of different soybean varieties immediately after harvest were subjected for storage. In all the varieties the dry weight of 100 seeds (15.99 to 19.78 g), the lab germination (99.2%), the field emergence (97.7%) and vigour index (4.65) were the highest and the electrical conductivity was the lowest (489 m mhos/cm) when the soybean crop was harvested after 75% of pods in most plants had turned yellow colour.

These results have indicated that optimum stage of harvesting soybean crop would be when 75 to 100% pods in the plant had attained yellow colour and with the beginning of whole plant drying but before pod shattering. In other harvest treatments in which only 25% or 50% of the pods per plant were in yellow colour, the 100 seed weight (14.2 to 18.7 g), the lab germination (72 to 85%), the field emergence (72 to 84%) and the vigour index (3.42 to 4.30) were the lowest and the electrical conductivity 686 to 895 umhos/cm was the highest indicating that the seed quality parameters were drastically reduced due to early harvesting when the seeds were still developing.

Thus early harvesting (when 25% or 50% pods per plant were still green) has reduced the seed quality parameters

even though there was no field loss of seeds due to shattering. Whereas when at least 75% of the pods per plant had turned yellow, the seed quality parameters were the highest and field shattering was also almost nil. This harvesting stage is found to be the best. When the first shattering commenced and also after 3, 6, 9 and 12 days after first shattering the initial germination (98 to 99 per cent) field emergence (96 to 97 per cent) and vigour index (4.41 to 4.63) were also fairly high but the field shattering loss of seeds significantly increased from 5 to 28 per cent, respectively.

These studies have revealed that the optimum stage of harvesting the soybean would be at least after 75 to 100 per cent of pods per plant have turned yellow but before the beginning of first shattering. This optimum stage of harvesting has not only maintained seed quality but also prevented field shattering loss.

The seeds harvested from different harvesting stages were stored over 8 months and studied for their germination and vigour behaviour. In the beginning of storage itself (at harvesting) the 100 seed weight, lab germination, field emergence, vigour index and the electrical conductivity differed among the harvesting stages and these effects were noticed even during the storage period. The seeds obtained

from H1 (25% of pods per plant in yellow colour and H2 (50% of pods per plant in yellow colour) recorded low lab germination, field emergence and vigour index not only from the beginning but also 240 days of after storage. All these seed quality parameters declined at a faster rate than that of H3 (75% of pods plant in yellow colour) or in H4 (the beginning of shattering). Like wise the seeds harvested after 3 days (H6), 6 days (H6), 9 days (H7) and 12 days (H8) after first shattering there was significant reduction in the lab germination, field emergence and vigour index only after storage. These results clearly indicate that seeds harvested much before physiological maturity as in H1 (25% of pods in yellow colour) and H2 (50% of pods in yellow colour harvesting stages) recorded low germination and vigour index not only from the beginning but also 8 months after storage. Likewise seeds obtained from delayed harvesting (H8) have lost germination and vigour after 8 months of storage. However, the seeds harvested from H3 (75% of the pods in yellow colour) and in H4 (the beginning of shattering) have maintained high germination and vigour index right from the beginning to the end of 8 months of storage.

These results have shown the importance of optimum stage of harvesting to prevent loss of seeds due to pod shattering and also to maintain the highest seed germination

and vigour right from harvesting and also in storage.

Similar observations have been made by different workers in case of soybean. Lompang (1972) reported that the seeds harvested when the lower leaves had fallen recorded the same germinability as that of seeds harvested after full maturity. Coelho et al. (1979) reported that the soybean seeds could be stored safely at 28°C and 66% RH since at this condition seed deterioration was the least.

Ortiz and Cianzio (1983) reported that the seeds harvested 5 to 6 weeks after flowering would give higher germination and field emergence. Carraro et al. (1983) observed that the seed quality was reduced more by rainfall before harvest than by delay in harvesting after maturity.

Amarak et al. (1983) reported that soybean seeds stored in jute, polythene and multilayered paper bags showed no initial difference between the containers but after 5 months of open storage seeds showed reduced germination and vigour.

Iglibias and Abreue (1984) reported that the optimum seed quality in variety Vavilov 63-17 was found at harvesting 10 days after 95% of pods were matured.

Larcher and Godon (1984) reported that the seeds stored in plastic bags maintained germination of 90% after 12

months of storage.

Prakob¹⁵oon and Naglor (1987) observed that the highest germination percentage (92.3%) was obtained with harvesting 55 days after 50% flowering with a corresponding moisture content of 31.4% . Harvesting before 50 days after 50% flowering significantly reduced the germination.

Kalavathi and Ramaswamy (1988) reported that the soybean seeds collected on the 55th day after 50 per cent flowering were found to be superior to those collected 40, 45, 50 and 60 days after 50 per cent flowering in germination percentage, root and shoot length.

Sripichitt (1989) reported that the seedling growth rate and hypocotyl length decreased gradually with increased storage period. Seed deterioration was rapid when seeds with 12 per cent moisture content were stored.

Adam and McDonald (1989) reported that late harvesting decreased the germination percentage, seedling growth rate whereas electrical conductivity of seed increased. These observations made by several workers are in agreement with the present findings.

SUMMARY

VI SUMMARY

In this chapter some of the conclusive results as emerged from studies concerning the seed development, maturation, storability on the seed quality of five different soybean varieties, viz., Monetta, PK 471, Bragg, Hardee and KHSb2 are summarised.

1. The soybean varieties grown during the rabi season 1990 (Sept-Dec) differed in their duration to flowering and physiological maturity. Monetta was the earliest and it flowered in 33 days and reached the physiological maturity in about 79 days from flowering. PK 471 and Bragg flowered in 37 days and reached physiological maturity in 85 days. Hardee flowered in 40 days and attained the physiological maturity in 89 days. KHSb2 was the longest. It took 43 days for flowering and 93 days for physiological maturity.

2. The dry weight of husk increased from 0.80 to 1.59 g/10 pods on 46th day from flowering and subsequently it decreased to 1.33 g/10 pods on 52nd day. The dry weight of husk differed among varieties at all stages of pod development. The husk weight was maximum in all varieties and it was attained 6 to 10 days before the seeds reached physiological maturity and it differed among varieties (Monetta: 1.50 g/10 pods, PK 471: 1.66 g/10 pods, Bragg: 2.55 g/10 pods, Hardee: 1.54 g/10 pods and KHSb2: 1.43 g/10 pods).

3. The dry matter distribution into the husk was the highest (86.12 %) on 15th day from flowering and it progressively decreased to 27.42 per cent with advance in the maturity of pods. The final dry matter distribution into the husk also differed among the varieties (Monetta:27.91%, PK 471: 25.88%, Bragg:28.23% Hardee:28.02% and KHSb2: 28.15%).

4. The dry weight of developing seeds consistently increased from 0.12 to 3.69 g/10 pods from 15 to 48th day from flowering and subsequently there was slight decrease (3.22 g/10 pods) on 52nd day. Varieties differed in their dry weight at all stages of seed development. The maximum dry weight was attained on 46th day in Monetta (2.86 g/10 pods), on 48th day in PK 471 (3.99 g/10 pods), Bragg (4.24 g/10 pods) on 50th day in Hardee (4.66 g/10 pods) and KHSb2 (3.06 g/10 pods).

5. The dry matter distribution into the seeds consistently and progressively increased from 13.88 to 72.58 per cent. The dry matter distribution into the seeds differed among the varieties (Monetta: 13.11 to 72.09%, PK 471: 18.29 to 74.12%, Bragg: 12.31 to 72.77%, Hardee: 11.76 to 71.98% and KHSb2: 13.97 to 71.84%).

6. The moisture per cent in the husk consistently decreased from 81.52 to 16.97 per cent during the course of pod devel-

opment. The same trend (85.8 to 26.37 per cent) followed in the developing seed also.

The developing seeds did not germinate from 15 to 30th day after flowering. However, the developing seeds germinated only from 35 days onwards and reached peak germination at their respective physiological maturity.

7. At physiological maturity the seed dry weight (Monetta: 2.86 g/10 pods, PK 471: 3.99 g/10 pods, Bragg: 4.24 g/10 pods, Hardee: 4.66 g/10 pods and KHSb2: 3.06 g/10 pods), the dry matter distribution into the seed (Monetta: 70.65%, PK 471: 71.78%, Bragg: 69.93%, Hardee: 69.42% and KHSb2: 71.14%), the germination percentage (Monetta: 99.50%, PK 471: 99.50%, Bragg: 100%, Hardee: 99.75% and KHSb2: 100%). The vigour index (Monetta: 4.74, PK 471: 4.98, Bragg: 4.52, Hardee: 5.56, and KHSb2: 5.28) were the highest. The moisture content in the seed also was fairly high (Monetta: 32.15%, PK 471: 44.52%, Bragg: 50.21%, Hardee: 41.81% and KHSb2: 43.82%). All these parameters differed among the varieties slightly.

8. The physiological maturity of the seeds was attained when 75 to 100 per cent of the pods per plant had turned yellow during maturation. The first field shattering of pods occurred when the varieties reached 82 to 105 days duration. The first field shattering was recorded 82 days after sowing

in Monetta, 92 days after sowing in PK 471 and Bragg, 103 days after sowing in KHSb2 and 105 days after sowing in Hardee.

The percentage of pod shattering was maximum in Monetta, medium in KHSb2 and Hardee, low in PK 471 and Bragg. The field shattering of pods after 12 days from first shattering was the highest in Monetta (11 to 64%) followed by KHSb2 (3 to 33%), Hardee (3 to 28%) and was lowest in PK 471 (4 to 12%) and Bragg (3 to 6%).

Monetta, KHSb2 and Hardee are more susceptible to field shattering while PK 471 and Bragg are fairly resistant to field shattering even if there is delay of 12 days in harvesting from the first shattering. Bragg is the more resistant for field shattering.

There was no shattering even when 75% of pods per plant had reached yellow colour during maturation. The first shattering in all varieties began when all the leaves had fallen down and the pods had dried and turned brown.

Irrespective of varieties, the 5 per cent of the pods per plant had shattered in the first shattering. With further delay by 3 days (6% of pods), 6 days (8% of pods), 9 days (23% of pods) and 12 days (28% of pods), the pod shattering increased significantly.

The first shattering of pods after physiological maturity differed among varieties (Monetta: 2 days, PK 471: 5 days, Bragg: 5 days and Hardee: 13 days and KHSb2: 7 days).

The 100 seed weight was maximum in Hardee (19.34 g) and PK 471 (18.73 g), medium in Bragg (16.63 g) and KHSb2 (16.24 g) and the lowest in Monetta (15.02 g). Generally the varieties which recorded the lowest 100 seed weight, recorded maximum shattering (Monetta and KHSb2).

Delayed harvesting beyond physiological maturity (75% to 100% of pods in yellow colour) decreased the 100 seed weight significantly (17.71 g to 17.32 g), lab germination (99.0 to 78.0%), field emergence (97.7 to 96.0%), vigour index (4.65 to 4.41) and increased electrical conductivity (489 to 498 umhos/cm).

Early harvesting (when 25% or 50% of pods are in yellow colour) before the physiological maturity also had drastically reduced 100 seed weight (14 g), lab germination (73%) field emergence (70%), vigour index (3.44) and increased electrical conductivity (895 umhos/cm).

9. The germination percentage (73 to 55%), the field emergence (72 to 47%) and vigour index (3.44 to 2.47) decreased and while the electrical conductivity increased (from 895 m. mhos/cm to 1812 m. mhos/cm) when soybean plants were harvested much before physiological maturity when 25% of pods

per plant had turned yellow). Likewise in 12 days delay in harvesting from the first shattering of pods (H8), the germination percentage (99 to 88%), the field emergence (96 to 82%) and the vigour index (4.41 to 3.91) decreased and while the electrical conductivity increased (498 to 1379 umhos/cm) drastically.

10. Soybean varieties have to be harvested during the period when 75 to 100 per cent of pods have attained yellow colour and the first shattering of pods is yet to begin (when most of the pods have turned brown with fair drying) for obtaining the highest germination and vigour index and also without any loss of seeds due to field shattering and also for maximum storability.

The seeds obtained from premature harvesting as in H1 (25% of pods in yellow colour) and H2 (50% of pods in yellow colour) were the most inferior both in their initial germination capacity, vigour and storability even though the shattering loss of seeds was nil. In delayed harvesting from 2 to 12 days after physiological maturity, the field shattering of pods increased tremendously from 0 to 28% and the storability of seeds increased but the storability of seed obtained from 9 days (H7) or 12 days (H8) after first shattering decreased significantly.

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VIII REFERENCES

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* Originals are not seen.