"STUDIES ON POPULATION AND THINNING OF MAIZE CROP - ON FORAGE AND GRAIN PRODUCTION"

BY

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THESIS SUBMITTED TO THE
ANDHRA PRADESH AGRICULTURAL UNIVERSITY
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF

MASTER OF SCIENCE IN AGRICULTURE
(SEED SCIENCE AND TECHNOLOGY)

DEPARTMENT OF GENETICS AND PLANT BREEDING
COLLEGE OF AGRICULTURE, RAJENDRANAGAR
ANDHRA PRADESH AGRICULTURAL UNIVERSITY
RAJENDRANAGAR, HYDERABAD - 500 030

1990

CERTIFICATE

Mr. I. SARVESWARA RAO, has satisfactorily prosecuted the course of research and that the thesis entitled **"STUDIES ON POPULATION AND THINNING OF MAIZE CROP - ON FORAGE AND GRAIN PRODUCTION"** is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by him for a degree of any university.

Date : -10-1990

(Dr B. LINGAM)
Major Advisor

C E R T I F I C A T E

This is to certify that the thesis entitled **"STUDIES ON POPULATION AND THINNING OF MAIZE CROP - ON FORAGE AND GRAIN PRODUCTION"** submitted in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE IN AGRICULTURE** of the Andhra Pradesh Agricultural University, Hyderabad, is a record of bonafide research work carried out by **Mr I. SARVESWARA RAO**, under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee.

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

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LIST OF ABBREVIATIONS

°C	:	Centigrade
CD	:	Critical difference
Cm	:	Centimeter
Cm^2	:	Square centimeter
Cv	:	Cultivar
DAS	:	Day after sowing
g	:	Gram
ha	:	Hectare
kg ha^{-1}	:	Kilogram per hectare
m	:	Metre
m^2	:	Square metre
mg	:	Milligram
NS	:	Not significant
q	:	Quintal
q ha^{-1}	:	Quintals per hectare
RH	:	Relative humidity
SE	:	Standard Error
t	:	Tonne
t ha^{-1}	:	Tonnes per hectare
%	:	Per cent

ACKNOWLEDGEMENTS

It is a great previlege for me to express my deep sense of gratitude, indebtedness and sincere thanks to **Dr. B. Lingam**, Associate Professor, Department of Agronomy, College of Agriculture, Rajendranagar, Hyderabad for being Chairman of the Advisory Committee, for his patient attitude, affectionate guidance, sustained interest, constructive criticism, generous help and constant encouragement at every stage of endeavour without his able guidance and valuable suggestions, this work would not have been seen the light of the day.

I extend my sincere thanks to **Dr. M. Bala Krishna Reddy**, Forage Breeder, AICRP on Forage Crops, for being one of the Member of my Advisory Committee, for his valuable suggestions and preparation of this thesis.

I am profoundly indebted to **Dr. B. Muralimohan Reddy**, Seed Research Officer, Seed Technology Research Project, A.P. Agricultural University, Rajendranagar, Hyderabad, for being Member of my Advisory Committee, for providing the required facilities to carry out this investigation and for his incredible, immeasurable and untiring help, incisive criticism and precious guidance in the successful completion of this thesis work.

My profound gratitude should also go to **Dr. Shaik Mohammed**, Agronomist (sorghum), RARS, Palem, Mahaboobnagar (Dist.), for his timely suggestions and guidance at every stage of the investigation.

I am very much thankful to **Dr. R. Ankaiah**, Asst. Research Officer, Seed Technology Research Project, Rajendranagar, Hyderabad, for his patient, valuable suggestions in the correction of manuscript and refining my effort to complete this thesis.

My sincere thanks are due to **Dr.M.S.S. Reddy**, Principal, Professor & Head, **Dr.M.Lawrence**, Associate Professor and other staff members of Department of Genetics and Plant Breeding, College of Agriculture, Rajendranagar for their kind help and cooperation during the course of my studies and research work.

I also extend my sincere thanks to **Dr.K.Chaitanyam**, Senior Scientist, AICRP on Poultry for Eggs (ICAR) and other staff members of Seed Technology Research Project, Rajendranagar, Hyderabad for their cooperation.

My sincere and heartfelt thanks are due to my beloved parents **Sri I. Lazarus and Smt. Kamalamma**, for their constant encouragement during my study period and life.

I express my heartfelt thanks to my father-in-law **Sri G.J.Christopher** and mother-in-law **Smt. Sarojini**, for their encouragement and moral support.

I am very much thankful to **S. Venkat Reddy**, Ex-Director, A.P.S.S.C.A., Hyderabad, for providing deputation facilities and suggestion for investigation of the present experiment. I am also grateful to **Dr. R.N. Subba Reddy**, Director, A.P.S.S.C.A., Hyderabad, for providing facility to successfully complete my thesis work.

I am very much thankful to **Dr. K.Butcha Reddy**, Farm Superintendent, **Sri Ramachandra Rao**, Farm Manager, College Farm and **Sri Khaja Shareef**, Agricultural Assistant, Plant Breeding Department for his help in the field experiment.

I offer my sincere thanks to **V. Munaswamy, J. Dilip Babu,** S.**O.A.Malik**, **Madhavi** and staff members of the Department of Agronomy, College of Agriculture, Rajendranagar, for their kind help during my research work.

I express my appreciation to my beloved wife **Smt. G. Sujata**, for the inspiration, co-operation and encouragement during my study period and life, finally I would like to acknowledge my sons **Raj Kiran (Chinnu) and Ravi Kiran.**

I am very much beholden and profoundly indebted to my affectionate brothers and my sisters and brothers-in-law and sisters-in-law, for their ever losting love and who have constantly been a great source of encouragement and inspiration in the pursuit of my studies and my life.

I am also thankful to my colleagues **Sri Mallikarjun Rao** (APSSDC), Benerjee, Krishna Murthy, Natarajan, Mrs. Sulochana and **Venu Gopal Reddy**, for their cooperation and help during the course of my study.

I acknowledge the help and facilities received from the A.P.Agricultural University during course of study and research work.

I also extend my sincere thanks to **Sri A.Satyanarayana**, Research Officer and **Sri Hanmanthu**, Computer Centre, A.P. Agricultural University, for sparing their time in statistical analysis of the data.

Finally a word of appreciation goes to the staff of **COMPUTER NEURONS, RAJENDRANAGAR, HYDERABAD-30** for typing this manuscript neatly and efficiently in a record time.

(I. SARVESWARA RAO)

DECLARATION

I, **I. SARVESWARA RAO**, hereby declare that the thesis entitled **"STUDIES ON POPULATION AND THINNING OF MAIZE CROP ON FORAGE AND GRAIN PRODUCTION"** is result of the original research work done by me. It is further declared that the thesis or any part thereof has not been published earlier in any manner.

Date : -10-1990

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Degree to which it it submitted : MASTER OF SCIENCE IN AGRICULTURE

Faculty : AGRICULTURE

Descipline : SEED SCIENCE AND TECHNOLOGY

Major Advisor : Dr. B. LINGAM

University : ANDHRA PRADESH AGRICULTURAL UNIVERSITY

Year of submission : 1 9 9 0

ABSTRACT

Present investigation was carried out at College of Agriculture Farm, Rajendranagar, Hyderabad during rabi 1989-90 season with 3 varieties (Ganga-5, DHM-103 and African tall) at 3 spacing levels (60 x 25 cm; 45 x 15 cm; 30 x 15 cm) as main treatments and 5 thinning treatments i.e., thinning at 30, 45, 60 and 75 days after sowing including control (without thinning) as sub-treatments in a split plot design.

Vertical growth in terms of plant height, dry matter production of African tall was very rapid compared to Ganga-5 and DHM-103, with age of the crop and significantly differed with other at 75 DAS and at harvest in plant height; at 90 to 120 DAS and at harvest in dry matter production. African tall took more number of days for 50 per cent tasselling and silking than Ganga-5 and DHM-103. Ganga-5 superior in yield attributes of number of cobs per plant, and number of grains per cob, cob weight, grain yield compared to African tall and DHM-103. Gross returns per hectare due to cumulative values of grain, stover and forage were maximum in Ganga-5 (Rs 9,492) which was Rs 1142 and Rs 423 higher than that of African tall and DHM-103, respectively.

Dry matter production per plant, number of cobs per plant, number of grains per cob, cob weight, yield per plant gradually decreased with decreasing of spacing from 60 x 25 cm to 45 x 15 cm and 30 x 15 cm in all varieties. However in all cultivars tried, per unit area concerned, yield of grain, stover and forage; gross monetary returns were high in highest population level or narrow spacing (30 x 15 cm). An increase of monetary returns over normal population with highest plant density (2,22,222 plants ha^{-1}) was Rs 1,564 (18.06%) in Ganga-5, Rs 2,148 (27.15%) in DHM-103 and Rs 2,937 (43.10%) in African tall. African tall found to be very responsive to plant population for obtaining highest monetary returns when compared to Ganga-5 and DHM-103.

Thinning is a matter of promise that by putting more plants initially and thinning them later not affected the prospects of plant height, dry matter production, grain number per cob, cob weight and yield of grain and stover returns. However, there was a significant improvement of forage and gross monetary returns with thinning treatments when compared to control. Thinning at 30 and 45 DAS improved the total returns (due to grain, stover and forage) to a maximum possible extent in Ganga-5 which was statistically on par to improvements made in DHM-103, inturn both were superior to African tall. Irrespective of thinning treatments, plants grown under wider spacing of 60 x 25 cm recorded higher values in dry matter production, number of cobs per plant, number of grains per cob and cob weight per plant when per compared with 45 x 15 cm and 30 x 15 cm. However, when per hectare is considered, change in population rate due to spacing from 60 x 25 cm to 45 x 15 cm and 30 x 15 cm resulted in higher gross monetary returns due to grain, stover and forage yield in all thinning treatments.

INTRODUCTION

CHAPTER I

INTRODUCTION

Maize is an important cereal crop grown for grain, stover and forage production. Its utility as food for human beings, feed for animals and industrial use. The average grain yields of maize in kilograms per hectare are 7,318 in Italy, 6,898 in USA and 2,999 in China. India ranks sixth (5.54 million hectares) in world acerage while its total production (5.63 million tonnes) occupies tenth place. The contribution of Andhra Pradesh is 5.8 per cent in respect of area which its production comes to an extent of 11.3 per cent in India.

The Indian National Commission on Agriculture on maize estimated the requirement of maize by 1988 would be in the order of 12.75 to 14.29 million tonnes. To reach this target, the production has to be nearly doubled within next few years.

In Andhra Pradesh maize is grown under rainfed as well as under irrigated conditions. The crop is cultivated in an area of 3.3 lakh of hectares. The crop being important for the grain for food and the resultant starch and other products, like glutine which are utilised in industry. Further the grain is highly marketable, utilised as feed constituent to an extent of

40 to 50% of concentrate formulations of livestock and poultry. The stover, though poor in quality as fodder, is being utilised for feeding the cattle. The green crop as forage for cattle usage is treated as ideal forage plant with good growth as well as production without any anti-metabolites as such could be harvested at any stage of crop.

Being a row crop, a ceiling is generally felt in deciding the population for successful grain production. Accommodating both the necessities i.e., grain as well as forage, one has to find a way for these two purposes. One of the factors limiting grain yield of maize in many areas is low plant population.

In general as plant density increases, the grain yield improves to a maximum, which remains constant for sometime and declines more or less steeply when population pressure increases, still further (Choudhary, 1981; Remison and Lucas, 1982; Raghotham Reddy 1984; Krishna Veni and Ramaswamy, 1985 and Tano et al., 1987).

A compatable system has to be identified by growing high population initially and thinning at various stages which can result in good grain production as well as green forage. Exploiting genetic potentiality through agrotechnology like removal of alternate hills (thinnings) and utilization of removed hills as a forage

(Arnel *et al*., 1969; Wang *et al*., 1987), selection of superior genotypes adaptable to varied agro-climatic conditions and exploiting for both necessary needs of grain and forage (Krishnamurthy *et al*., 1974a; Sharma, 1978, Raghotham Reddy 1984).

The emphasis is now on producing optimum food grains and stover as well as forage for feed to the animals and livestock. Thus keeping in view of both the needs of grain, stover and forage the present investigation was carried on with the following objectives:

1. To fix up the suitable population required for grain as well as forage production, separately and in combination with each other.

2. To identify the thinning stage which can give the normal grain yield i.e., population and stage of thinning which is not detrimental for the grain production.

3. To identify the production of forage, which could be obtained for feeding the cattle.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Maize is an important crop for grain as well as fodder production, under rainfed and irrigated management in Andhra Pradesh. Being a row crop, a ceiling is generally felt in deciding the population for successful grain productions. Accommodating both the necessities i.e., grain as well as green forage, a compatable system has to be identified which can result in good grain production as well as green forage for atleast for some period. In the present chapter, a brief review of the work on effect of population and thinning on forage andgrain production was emphasized.

2.1 PLANT HEIGHT

2.1.1 Effect of population on plant height

Several researchers reported that plant height increase with increased of plant densities. Verma and Bhatnagar (1962) showed that population ranging from 18,520 to 55,555 plants per hectare recorded a significant improvement in plant height from 164 to 173 cm. Giesbrecht (1969) stated that there was an increase in plant height from 193 cm to 198 cm with higher population from 45,000 to 75,000 plants per hectare.

Taneja *et al.* (1984) opined that seed rates of 30, 45, 60 and 75 kg/ha failed to show significant difference in plant height.

Dostalek and Hruska (1985) recorded that at higher crop densities the plant height was increased. Krishnaveni and Ramaswamy (1985) observed that plant height increased with increased population (decreasing spacing) levels from 60 x 30 cm (121 cm) to 60 x 25 cm (120 cm), 60 x 20 (122 cm), 45 x 30 cm (126 cm) and 45 x 25 (129 cm) in COH-1 hybrid maize.

Singh and Tajbakhsh (1986) reported that plant density from 50 to 100 thousand plants per hectare does not influence on the plant height in Partap, Sangam, Ganga-5 varieties of maize.

2.1.2 Effect of Thinning On Plant Height

Arnel *et al.* (1969) reported that thinning at the 5 to 8th and 9 to 11th leaf stage showed no difference in height when compared to control (no thinning treatments).

Shafshak *et al.* (1984) observed that early thinning at 15 DAS increased plant height in the remaining plants as compared to late thinnings at 20 DAS, 25 DAS and 30 DAS.

2.2 EFFECT OF POPULATION ON DRYMATTER PRODUCTION

Stivers *et al.* (1971) reported that per plant dry weight was low with higher population levels, whereas per hectare dry matter gradually increased with increase of population from 54,000 plants hectare (15,205 kg ha^{-1}) to 69,000 plants per hectare (15,813 kg ha^{-1}). Pucaric and Gotlin (1973) discovered that there was a decrease in drymatter production per plant with increase in population from 62,112 plants ha^{-1} to 75,188 plants ha^{-1} in BC 21-22, BC SK-5A and BC 68-22 maize hybrids whereas per hectare yield was increased with increase of plant population. Alessi and Power (1974) showed that higher population levels significantly affect drymatter production per plant.

Krishnamurthy et al. (1974b) reported that there was a significant reduction of dry weights of plant,as plant density increased from 45,000 plants ha^{-1} (49 g) to 75,000 plants ha^{-1} (24 g).

Raghotham Reddy (1984) observed that there was a gradual reduction of dry weight per plant with increase of plant density from 59,259 plants per hectare (213 g) to 66,666 plants per hectare (204 g) and 88,888 plants per hectare (173 g). However per hectare yield was increased with increase of plant population from 59,259 plants ha^{-1} (42.07 q ha^{-1}) to 66,666 plants ha^{-1} (45.33 ha^{-1}) and 88,888 plants ha^{-1} (51.23 q ha^{-1}).

Taneja et al. (1984) observed that there was a decrease in plant dry weight with increase of seed rate from 30 kg to 75 kg per hectare, whereas per hectare dry matter increased from 84 q per hectare to 97 q per hectare.

Singh and Tajbakhsh (1986) observed that there was a negative association between plant dry weight and plant densities, while per hectare dry matter had a positive association with higher plant densities.

Wang et al. (1987) observed that plant dry weight increased with decreasing plant density.

2.3 DAYS TO 50 PER CENT SILKING AND TASSELING

Aguila and Violic (1971) observed that silking date was delayed as plant density increased from 55,000 to 85,000 plants per hectare.

Krishnamurthy et al. (1974) reported that days to 75% silking was early by 2 days in 60,000 plants per hectare compared to 80 days in 75,000 plants per hectare.

Rathore et al. (1976) observed that the tasseling and silking differences with plant population interaction were non-significant. While Athar (1979) showed that days to 50 per cent silking increased with increase in plant population.

2.4 YIELD ATTRIBUTES

2.4.1 Effect of Population on Yield Attributes

2.4.1.1 Grain number per cob

Bianco and Caliandro (1973) reported that the number of grains per cob decreased with increase of plant density from 4 to 6 and 8 plants per square meter.

Rathore et al. (1976) observed that higher population levels affect grain number per cob which ranged from 395 g with 20,000 plants ha^{-1} to 355 g with 80,000 plants ha^{-1}.

Al-Rudha and Al-Younis (1978) observed that narrow row spacing of 50 cm affected number of grains per cob as compared to wider row spacing of 90 and 79cm.

Shukla et al. (1978) observed significant decrease in number of grains per cob from 552 to 424 and 1000 grain weight with increase in population density to 70,000 than compared to 50,000 per hectare.

Reddy et al.(1987) showed that increased density from 59,200 to 88,800 plants per hectare, decreased number of grains per cob.

Mannino and Tano (1988) observed that number of grains per cob decreased with increase of plant density from 5.5 plants to 6.5 plants per square meter.

2.4.1.2 Cob weight

Novais *et al.* (1971) observed that ear weight decreased with increase in plant density while Rathore *et al.* (1976) observed decreased cob weight from 117.8 g to 106.2 g, 95.6 g and 87.7 g with increase in plant population from 20,000, 40,000, 60,000 and 80,000 plants per hectare, respectively. Tianu (1976) stated that grain weight per cob decreased as plant density increased from 40,000 to 70,000 plants per hectare.

Al-Rudha and Al-Younis (1978) observed that narrow row spacing 45 and 30 cm row spacing affected cob weight when compared with wider row spacing of 79 and 90 cm.

Choudhary (1981) observed cob weight of NCA maize cultivar which registered significantly lower value 103 g with high plant density of 92,600 per hectare when compared with low plant density of 37,000 per ha^{-1} (169 g).

Remison and Lucas (1982) observed significantly smaller cobs interms of length and diameter, reduced cob weight and decrease in number of grain rows per cob with FARZ-23 maize cultivar with almost doubling the population from 37,000 to 80,000 per hectare.

Krishnaveni and Ramaswamy (1985) noted that cob weight was decreased with decrease of spacing of 45 x 25 cm (78 g), 45 x 30 cm (84 g) when compared with wider spacing of 60 x 20 cm (96 g), 60 x 25 cm (99 g) and 60 x 30 cm (111 g).

Roy and Singh (1986) observed grain weight per ear decreased with increase in plant population from 60,000 to 80,000 plants per hectare.

2.4.1.3 Grain weight

Goydani and Singh (1968) revealed that the grain weight of 237.3 g recorded with 50,000 plants per hectare was significantly reduced to 205.3 g with doubling the population density to 1,00,000 plant per hectare.

Sharma and Gupta (1968) observed that maintaining population density of 70,000 per hectare recorded significantly reduced grain weight per cob of 111.6 g compared to 124 g in 50,000 per hectare.

Krishnamurthy et al. (1974 a) observed that the population from 55,000 to 83,000 per hectare resulted in decrease 127 to 106 g for grain weight per cob.

Krishnaveni and Ramaswamy (1985) observed seed weight was decreased with closer spacings when compared with wider spacings. The per cent reduction in test weight with closer spacings over wider spacing (60 x 30 cm) was 30.26, 27.56 and 16.99 with 45 x 25; 45 x 30 and 60 x 25 cm; respectively.

Singh and Tajbakhsh (1986) recorded that there was a decrease in 1000 grain weight with increase of plant population from 50,000 (223 g); 75,000 (212 g) and 1,00,000 plants per hectare (212 g).

Lascu (1987) noted decrease in 1000 grain weight with increased plant densities from 45,000 to 60,000 plants per hectare.

Reddy *et al*. (1987) observed increasing density of plants from 59,200 to 88,800 plants per hectare decreased 1000 grain weight.

Tano *et al*. (1987) observed that increasing plant densities reduced the grain weight and grain number per each cob.

2.5 YIELD

2.5.1 Effect of Population on Grain Yield

Gonzalez and Porras (1968) observed that grain yields per hectare was more with closer spacing of 45 x 30 cm (7.2 t ha^{-1}) when compared with wider spacing of 60 x 30 cm (7.0 t ha^{-1}).

Sharma and Gupta (1968) reported that grain yield per hectare was maximum under 50,000 plants per hectare (51.97 q ha^{-1}) in 1964-65 and (41.66 q ha^{-1}) in 1965-66 which was 11.65 and 22.83 per cent more than the yields obtained from 40,000 plants per hectare during the two years.

Giesbrecht (1969) conducted experiment with early corn hybrids of Dekalb VL 301, Dekalb VL 302, Morden 77, Morden 88 were grown at populations of 30,000, 45,000, 60,000 and 75,000 plants per hectare at each of the spacings of 50, 65, 80 and 95 cm between rows. The results from means of all hybrids indicated that each increase in population from 30, 45, 50, 60 and 75 thousand population produced a substantial improvement in grain yield from 40.76; 52.48; 60.82 and 61.70 q ha^{-1}, respectively.

Singh and Leng (1970) observed that, grain yield positively increased with increase of plant population from 24,686 (45.52 q ha^{-1});34,651 (56.19 q ha^{-1}); 44,839 (67.49 q ha^{-1}), up to 55,030 (68.21 q ha^{-1}). Thereafter reduction in yield was observed with 65,221 plants per hectare (63.45 q ha^{-1}).

Verma and Singh (1970) observed a grain yield of 2,782 kg per hectare under 90,000 plants per hectare which was significantly higher by11.55 and 35.84 per cent than 60,000 and 40,000 plants per hectare, respectively.

Kalbhor and Chagule (1971) observed that highest average grain yield of 4.61 t ha^{-1} was recorded by crop sown at highest plant density of 65,245 plants per hectare, which was significantly superior to low plant densities of 61,157 plants per hectare (4.47 t ha^{-1}) and 49,277 plants per hectare (4.23 t ha^{-1}).

Prithviraj et al. (1971) indicated that under Karnataka conditions a higher plant population with 60 x 18 cm spacing recorded higher yield compared to low plant population with 60 x 36 cm spacing and that Deccan yielded more than Amber with a higher fertilizer dose.

Verma and Singh (1976) observed that increasing the plant density from 45,000 to 90,000 plants per hectare increased the yield (Ganga-3 and Ganga-101) from 2.05 to 2.78 t ha^{-1}.

Azevedo (1973) observed that yield was positively correlated with plant density, which ranged from 38,000 to 1,08,700 plants per hectare.

Jain et al. (1975) observed increased yields upto 60,000 plants ha^{-1}.

While Meenakshi et al. (1975) stated that "Deccan hybrid" gave the highest and almost the same yield in both the spacings i.e., 40 x 25 cm (68.44 q ha^{-1}) and 60 x 30 (68.61 q ha^{-1}) which were significantly superior to wider spacing of 80 x 30 cm (63.19 q ha^{-1}).

Jobim *et al.* (1976) reported that grain yield increased from 2.94 to 3.83 t ha^{-1} with increase in plant population from 25,000 to 41,500 plants ha^{-1}, respectively.

Where as Verma and Singh (1976) recorded increasing yield at Udaipur upto 85,000 plants ha^{-1} with Ganga Safed-2 hybrid.

Razuvaev (1981) reported that there was an increase grain yield with increase of plant population from 40,000 to 70,000 plants ha^{-1} in three maize hybrids.

Buragohain and Kalita (1985) observed that narrow spacing (45 x 20 cm (1,11,111 plants ha^{-1}) which acommodated more plants per hectare resulted in a significantly increased grain yield over wide spacing of 60 x 30 cm (55,555 plants ha^{-1}).

Navarro *et al.* (1985) recorded that grain yield was increased with increase of plant population from 55,000 to 1,00,000 plants per hectare with CV. P-3311 at Cardoba.

Bakelana *et al.* (1986) stated that population density significantly influenced grain yield with maximum yield at a population density of approximately 68,910 plants per hectare.

While Singh and Tajbakhsh (1986) observed that highest grain yield (34.8 q ha^{-}) recorded with 75,000 plants per hectare, which was significantly higher than 50,000 plants per hectare (28.0 q ha^{-1}) but was on par with 1,00,000 plants hectare (33.1 q ha^{-1}) from the mean values of Pratap, Sangam and Ganga-5.

Moosa and Al-Younis (1987) observed that a plant density of 80,000 plants ha^{-1} with 100 cm inter row spacing gave the highest grain yield of 2.30 and 5.33 t ha^{-1} for spring and autumn growing seasons respectively. For every 20,000 plants ha^{-1} increase in plant density in the autumn grain yields increased by 1.19 t ha^{-1}.

Reddy and Raja (1988) reported 66,000 plants ha^{-1} as optimum for realising optimum yield. West et al. (1989) reported with maize cultivars sown at plant densities of 14,500; 17,400; 21,800; 27,600 and 30,500 plants/acre and indicated that grain yield increased with increase of plants density in all maize cultivars at Knoxville.

2.5.2 Thinnings On Production

Arnel et al. (1969) observed that plant and ear height decreased with the later stages of thinning (of 2 to 3, 5 to 8, 9 to 11 leaf stage) and control (without thinning) on plant stand yield and observed that yields of the control plots were not significiantly different from the yield obtained on the plots. Thinning at 5 to 8 and 9 to 11 leaf stage resulted in significiantly lowering yields than thinning at the 2 to 3 leaf stage. Thinning at different stages did affect yield of grain significantly.

Glenn and Daynara (1974) studied in a field experiment with United 106 and "Priete 116" were sown at the same time with the required seed rate and differentially thinned in early stages only. When the plants were above 60 cm in height, uniform thinning and non-uniform thinning was done. The plants of intermediate stature resulted in higher yield, particularly at high plant density (1,03,200 plants ha^{-1}) c red to non-uniformly thinned plants, where tall a short plots were selected alternately. Average acro the 2 cultivars and plant densities (51,600 and 1,03,20 plants ha^{-1}), uniformly thinned plots resulted in a 5.5 per cent increase in grain yield.

Shafshak et al. (1984) carried out a field experiment with maize thinning to plant/hill at 15, 20, 25 and 30 days after sowing and observed that early thinning i.e., at 15 days after sowing resulted in the highest grain yield of 188 and 211 g/plant in 1981 and 1982 respectively, through increase of yield components i.e., plant height, number of grains/ear, ear weight and

100-grain weight. Early thinning produced the highest dry root weight and resulted in early tasselling and silking.

Soelaeman et al. (1987) studied the effect of thinning from 1,00,000 to 50,000 plants/ha at 4th and 3rd leaf growth stages revealed that grain yield, fresh forage and total grain and forage,

crude protein decreased with time of thinning, while fresh forage increased in Cv IPB 4 and Arjuna. Highest economic returns were obtained from plots treated with 300 kg N/ha and thinned at 3rd leaf growth stage and 225 kg N/ha at 3rd leaf stage thinning for IPB 4 and Arjuna respectively. They were 73% and 20% higher than returns of 'control' plot.

Wang et al. (1987) studied maize hybrid, Tainung 351 which was grown at plot spacings of 80 x 10 cm (1,25,000 plants ha^{-1}); 80 x 20 cm (62,500 plants ha^{-1}); 80 x 40 cm (31,250 plants ha^{-1}). The higher densities were thinned to the lower densities at silking and 2 weeks later. The thinning treatments generally gave higher yield than the unthinned stands at the same final plant densities and gave greater partition of assimilate to ears.

Reddy and Raja (1988) reported that recommended thinning was at 10 days after emergence for maintaining optimum plant stand. Thinning at 20 and 30 days after emergence reduced the grain yield.

2.5.3 Stover Yield

Bapna and Trivedi (1971) stated that maintaining population density of 61,750 plants ha^{-1} significantly resulted in improved stover yield over 41,650 and 50,500 plants ha^{-1}.

Krishnamurthy et al. (1974) reported that stover yield increased signifciantly from 5,195 to 5,901 kg ha^{-1} with increase in population level from 45,000 to 75,000/ha, respectively. Population studies conducted on Ganga Safed-2 revealed that either maintaining population density of 75,000 and 85,000 ha^{-1} increased the stover yield by 25.9 per cent and 33.9 per cent, respectively over 5,989 kg ha^{-1} with 65,000 plants ha^{-1} (Verma and Singh, 1976).

Raghotham Reddy (1984) observed that considerable increase in stover yield from 10,550 to 14,540 kg ha^{-1} was obtained with a population per ha of 1,00,000 over 50,000 plants ha^{-1}.

Singh and Tajbakhsh (1986) reported that stover yield increased with increase of plant density from 50,000 plants/ha (75.7 q ha^{-1}) to 75,000 plants ha^{-1} (85.6 q ha^{-1}) and 1,00,000 plants ha^{-1} (93.0 q ha^{-1}) from the mean values of Pratap, Sangam and Ganga-5.

Amoruwa et al. (1987) reported the increased stover yield with increase of plant population.

MATERIALS AND METTHODS

CHAPTER III

MATERIALS AND METHODS

The present investigation entitled **"Studies on population and thinning of maize crop - on forage and grain production"** was conducted at Agricultural College Farm, Rajendranagar during rabi, 1989-90 in a split plot design, replicated twice. Rajendranagar is situated at 17-19°N latitude, 78.23 east longitude and at an elevation of 542.6 meters above mean sea level (MSL) having a semi-arid climate. Details of materials, methods and techniques used are given in this chapter.

3.1 SOIL

The field experiment was laid out in sandy clayey loam soil. the data on physico-chemical analysis of soil sample drawn at 0-30 cm depth from the experimental field before sowing of the experimental crop are given as follows:

3.1.1 Physical Properties of Soil

Mechanical composition (International Pipette Method, Piper, 1964).

Sand	...	61.2 per cent
Silt	...	16.1 per cnet
Clay	...	22.7 per cent

3.1.2 Chemical Properties

Soil reaction (pH) ...	6.5
Available nitrogen ...	200 kg ha^{-1}
Available phosphorus...	10 kg ha^{-1}
Available potassium ...	150 kg ha^{-1}

3.2 CLIMATIC CONDITIONS

Seven days mean of materiological data viz., maximum and minimum temperature, relative humidity and total rainfall etc., prevailed during the entire crop growth period are presented in Appendix-I.

3.3 EXPERIMENTAL DETAILS

A field experiment was conducted with Ganga-5, DHM-103 and African tall which are extensively grown for grain, stover and forage purposes. The study was conducted in split plot design with three varieties: Ganga-5, DHM-103 and African tall at three spacings: 60 x 25 cm, 45 x 15 cm and 30 x 15 cm as main treatments and five thinning treatments as sub-tratments, replicated twice. The following are the details of the experiment.

3.3.1 Details of Treatments

Main treatments - varieties at three spacings

Varieties	Spacings
V_1 - Ganga-5	S_1 60 x 25 cm (66,666 plants ha^{-1})
V_2 - DHM-103	S_2 45 x 15 cm (1,48,148 plants ha^{-1})
V_3 - African tall	S_3 30 x 15 cm (2,22,222 plants ha^{-1})

Sub-Treatments: Thinning Treatments

Thinning treatments : 5

T_1 - without thinning (control)

T_2 - thinning at 30 days after sowing

T_3 - thinning at 45 days after sowing

T_4 - thinning at 60 days after sowing

T_5 - thinning at 75 days after sowing

An additional treatment ~~was maintained~~ for forage harvest at 75 days after sowing (T_6).

Date of sowing	:	5-11-1989
Design	:	Split plot
Replications	:	2
Gross plot size	:	6.0 x 5.0 m (30 m^2)
Net plot size	:	3.6 x 3.5 m (12.6 m^2)

3.3.2 Imposition of Thinning Treatments

The required population levels of 66,666 plants ha^{-1}; 1,48,148 plants ha^{-1} and 2,22,222 plants ha^{-1} were obtained by adopting spacing of 60 x 25 cm, 45 x 15 cm and 30 x 15 cm respectively (by adjusting inter row spacing from 60 to 45 and 30 cm and intra row spacing from 25 cm to 15 cm).Thinning was done as per treatments as scheduled at 30, 45, 60 and 75 DAS. Alternate plants were removed mechanically so that the desired population was maintained in the respective treatments. The removed plants were collected, weighed and reported as forage obtained from respective treatment.

3.4 CULTIVATION DETAILS

3.4.1 Preparatory Cultivation

The field was brought to good tilth with tractor drawn disc plough, harrow and it was perfectly levelled. The ridge and furrows were formed as per the treatments (60, 45 and 30 cm apart) with a marker and 25 and 15 cm between plants with the help of marker.

3.4.2 Sowing

The seeds were dibbled at a depth of 2-3 cm from the base of the ridge at 25 and 15 cm inter-row spacing @ 2-3 seeds per hill. Irrigation was given immediatley after sowing for assured seed germination. After the establishment of seedlings, one plant per hill was maintained by removing extra plants.

3.4.3 Fertilizer Application

The recommended fertilizers @ 100 kg ha^{-1} Nitrogen in the form of urea, 50 kg ha^{-1} P_2O_5 in the form of single super phosphate were applied. Ten tonnes of farm yard manure per hectare, 20 kg N and entire P_2O_5 as super phosphate were incorporated at last harrowing in the soil with a cultivator. Nitrogen fertilizer was applied in three split doses (i.e. 20 kg ha^{-1} as basal dose, 40 kg ha^{-1} at 20 DAS and 40 kg ha^{-1} at 40 DAS).

3.4.4 Inter Cultivation

Atrataf 50% EC @ 1.5 kg ha^{-1} was sprayed as pre-emergence weedicide. Two hand weedings and one hoeing were given to keep the crop free from weeds. Earthing up was done at 30 days age.

3.4.5 Irrigation

Post-sowing irrigation was given to facilitate the germination, the second irrigation was given 10th day after sowing and thereafter, fortnightly irrigations were given.

3.4.6 Plant Protection Measures

Sparying with Endosulfan 35 EC at 0.07 per cent (2 ml/L) was done at 20 days after sowing against Spodoptera. Prophylatic measures were taken to prevent the stem borer by applying Furadon 5 G granules @ 2.5 kg per hectare in the leaf whorles at 25 DAS.

3.4.7 Harvesting

Before net plot harvesting, one row on both sides of plot and one plant in each row on either side was harvested as border crop. The plants in the remaining plot was harvested as net plot.

3.4.8 Threshing

Immediately after harvesting, cobs from net plots were dried for 15 days and threshed (shelled) by using bamboo sticks. The grain was cleaned before recording grain weight and moisture content of seed. The moisture content of seed was estimated by using stenlite moisture meter. Shelled seeds were subjected to sun drying until reaching to standard moisture content (11%) of the seed.

3.5 OBSERVATIONS AND DATA COLLECTIONS

The data were collected on various characters as detailed below:

3.5.1 Plant Population

Plant population was counted at 30, 45, 60 and 75 das after sowing.

3.5.2 Plant Height

Plant height was measured from the base to the tip of the last leaf of a plant in five plants at random in each treatment and each replication and expressed in centimeters (cm). Observations on plant height were recorded at 30 DAS, 45 DAS, 60 DAS and 75 DAS.

3.5.3 Dry Weight of Plant

Aerial plant parts of randomly selected two plants from each treatmental plot of each replication were collected at monthly intervals commencing from 30 DAS to harvest and separated into leaves, stems and cobs were oven dried at 80°C for a constant weight. The dry weight of different plant parts were put together and expressed as total dry matter production per plant expressed in grams (g).

3.5.4 Days to 50 per cent Tasseling and Silking

Total number of days required for 50 per cent tasselling and skiling were counted.

3.5.5 Yield Components and Yield

3.5.5.1 Number of Cobs per plant

Number of cobs per plant were counted in five plants at random in each treatment and each replication and average value was taken.

3.5.5.2 Cob Weight

Five cobs were randomly collected from each treatment in each replication and weighed in grams (g).

3.5.5.3 Number of Seeds per Cob

Five cobs were randomly selected from each treatment in each replication and harvested separately. The total number of seeds were counted after threshing and cleaning with the help of seed counter and the average value was taken.

3.5.5.4 100-Seed Weight

100-seeds from each replication in all the treatments were counted and weighed in grams (g) considered as 100-seed weight.

3.5.5.5 Grain Yield per Hectare

Plot yields of grain were recorded treatment-wise and replication-wise. The total yield per hectare was computed from plot yield of grain.

3.5.5.6 Stover Yield per Hectare

Plot yields of stover were recorded treatment-wise and replication-wise. The total yield per hectare was computed from plot yield of stover.

3.5.5.7 Forage Yield per Hectare

Plot yields of forage after thinning as per schedule were recorded treatment-wise and replication-wise. The total yield per hectare was computed from plot yield of forage.

3.5.5.8 Monetary Returns

Monetary returns were calculated according to price value of grain (Rs.150 q^{-}), price of stover (Rs.18 q^{-1}) and value of forage (Rs.18 q^{-1}). Gross monetary returns is the cumulative returns of grain, stover and forage.

3.6 STATISTICAL ANALYSIS

The data was subjected to statistical analysis following the method prescribed for split-plot design (Panse and Sukhatme, 1978).

RESULTS

CHAPTER IV

RESULTS

4.1 PLANT STAND

The differences between varieties, varieties vs thinning, varieties vs spacings, varieties vs spacing vs thinning treatments were not found statistically significant in respect of plant stand at all stages of crop growth.

Plant stand significantly increased with increase of plant population from S_1 (60 x 25 cm) to S_2 (45 x 15 cm) and S_3 (30 x 15 cm) at all stages of crop growth. During 30 DAS, the plant establishment was maximum with S_3 which was superior to S_2 and S_1. Therafter plant stand progressively declined in all population levels with advancement of the crop growth due to thinning (Table 1a).

There was a significant interaction between population levels and thinning treatments, wherever or whenever thinning done leading to reduction in plant stand. Such reduction with thinning treatments was more magnified in high plant densities of S_3 and S_2 as compared to low plant density of S_1 at all stages of crop growth (Table 1b).

Table 1a Effect of varieties, spacings and thinning treatments on plant stand ('000) at different stages of crop growth

Treatments		Days after sowing				
		Initial	30	45	60	75
	Varieties					
V_1	Ganga-5	127.654	110.410	99.954	89.404	69.538
V_2	DHM-103	127.782	117.159	106.287	95.532	69.610
V_3	Africantall	127.159	116.462	106.015	95.087	84.032
	SE $\pm$	0.069	0.033	0.039	0.043	0.049
	CD at 5%	--	--	--	--	--
	Spacings					
S_1	60 x 25 cm	64.321	58.221	52.166	45.999	39.832
S_2	45 x 15 cm	124.940	115.121	104.646	94.321	840.065
S_3	30 x 15 cm	193.337	177.553	161.887	145.776	129.665
	SE $\pm$	0.069	0.033	0.039	0.043	0.049
	CD at 5%	0.163	0.076	0.096	0.099	0.117
	Thinnings					
T_1	Control (No thinning)	130.480	130.480	130.480	130.480	130.480
T_2	Thinning at 30 DAS	126.276	73.443	72.443	73.443	73.443
T_3	Thinning at 45 DAS	126.433	126.433	72.777	72.777	72.777
T_4	Thinning at 60 DAS	127.290	127.295	127.290	72.952	72.952
T_5	Thinning at 75 DAS	127.174	127.174	127.174	127.174	72.952
	SE $\pm$	0.076	0.069	0.066	0.059	0.053
	CD at 5%	--	0.143	0.136	0.123	0.107

Note : The reduction on population from initial stage to 75 DAS is due to thinning treatments

Table 1b Effect of Spacing x Thinning (S xT) interaction on plant stand at 45, 60 and 75 days after sowing

Treatments	45 DAS			60 DAS			75 DAS		
	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
Thinnings :									
T_1 Control No thinning	65.832	127.832	197.775	65.832	127.832	197.775	65.832	127.832	197.775
T_2 Thinning at 30 DAS	33.333	73.665	113 333	33.333	73 .650	113.332	33.333	73.665	113.332
T_3 Thinning at 45 DAS	33.333	72.221	112.776	33.333	72.221	112.776	33.333	72.221	112.776
T_4 Thinning at 60 DAS	64.166	124.928	192.775	33.333	73.304	112.221	33.333	73.304	112.221
T_5 Thinning at 75 DAS	64.166	124.582	192.775	64.166	124.582	192.775	33.333	73.304	112.221
SE $\pm$			0.117			0.103			0.089
CD at 5%			0.236			0.213			0.187

Note : The reduction in population from initial stage to 75 DAS is due to thinning treatments

S1 : 60 x 25 cm (66,666 plants/ha); S2 : 45 x 15 cm (1,48,148 plants/ha);

S3 : 30 x 15 cm (2,22,222 plants/ha)

4.2 PLANT HEIGHT

The data on plant height under various treatments of varieties, spacings, thinnings and their interactions are presented in Table 2a and 2b. The pattern of growth in terms of plant height from the mean values of treatments indicated that the crop obtained 41 cm by 30th dayitself. Another 78 cm height was added during 45th day, 72 cm during 60th day and 49 cm during 75th day.

Plant height increased with age of the crop in all varieties of maize (Table 2a). The rate of increase in plant height (from 30 DAS to 45 and 60 DAS) was almost equal (above 70 cm) in all three varieties i.e., African tall, Ganga-5 and DHM-103. Thereafter (from 60 to 75 DAS) such increment in plant height was continued with only African tall with 76 cm as compared to Ganga-5 (33 cm) and DHM-103 (35 cm). At 75 DAS, a significant variation in respect of plant heihgt between varieties was observed. 'African tall' recorded maximum plant height (271 cm) which was significantly superior to Ganga-5 (223 cm) and DHM-103 (224 cm).

The interaction effect of varieties and thinnings in respect of plant height was found to be significant during 30 DAS (Table 2b). In Ganga-5 thinning at 30 DAS (T_2) recorded significantly higher plant height over control. Whereas in DHM-103, there was a significant

Table 2a Effect of varieties, spacings and thinning treatments on plant height (cm) at different stages of crop growth

Treatments		Days after sowing			
		30	45	60	75
	Varieties				
V_1	Ganga-5	40.10	116.30	187.30	222.50
V_2	DHM-103	42.00	117.60	190.60	223.90
V_3	Africantall	41.60	120.70	193.90	270.70
	SE $\pm$	0.81	4.37	3.01	7.88
	CD at 5%	--	--	--	18.20
	Spacings				
S_1	60 x 25 cm	40.30	117.80	193.30	244.20
S_2	45 x 15 cm	41.10	120.90	190.60	242.70
S_3	30 x 15 cm	42.30	116.00	188.10	230.20
	SE $\pm$	0.81	4.37	3.01	7.88
	CD at 5%	--	--	--	--
	Thinnings				
T_1	Control (No thinning)	41.70	118.90	189.90	235.10
T_2	Thinning at 30 DAS	40.90	116.50	193.30	238.20
T_3	Thinning at 45 DAS	41.40	120.50	189.00	238.30
T_4	Thinning at 60 DAS	41.60	118.10	191.60	244.10
T_5	Thinning at 75 DAS	40.60	117.20	189.30	239.20
	SE $\pm$	0.95	2.21	3.21	5.71
	CD at 5%	--	--	--	--

Table 2b Effect of varities x thinning (V x T) interaction on plant height at 30 days after sowing

Treatments			Thinnings				
			T_1	T_2	T_3	T_4	T_5
	Varieties						
V_1	Ganga-5		37.7	42.9	40.3	40.1	39.4
V_2	DHM-103		45.5	4[illegible].1	41.3	41.1	41.0
V_3	Africantall		41.9	38.6	42.5	43.8	41.4
	SE $\pm$						1.6
	CD at 5%						3.3

Table 2c Effect of varities x spacing x thinning (V x S x T) interaction on plant height at 75 days after sowing

			Thinnings				
			T_1	T_2	T_3	T_4	T_5
V_1	S_1		222.8	236.3	233.3	241.3	217.5
	S_2		243.3	207.1	204.8	225.6	239.3
	S_3		203.0	230.0	216.6	200.2	210.6
V_2	S_1		238.5	21[illegible].1	228.0	225.5	209.4
	S_2		215.6	236.0	224.1	231.9	228.5
	S_3		217.2	209.2	222.3	211.8	241.0
V_3	S_1		250.3	287.7	294.7	290.3	273.6
	S_2		263.5	262.8	287.4	282.5	287.3
	S_3		262.6	255.1	233.9	28[illegible].4	245.7
		SE $\pm$					7.1
		CD at 5%					4.8

T1 Control No thinning
T2 Thinning at 30 DAS
T3 Thinning at 45 DAS
T4 Thinning at 60 DAS
T5 Thinning at 75 DAS

S1 60 x 25 cm (66,665 plant/ha)
S2 45 x 15 cm (1,48,148 plant/ha)
S3 30 x 15 cm (2,22,222 plant/ha)

reduction of plant height with thinning treatments when compared with control. While in African tall thinning had no impact on plant height.

The interaction effect of $V_3S_1T_3$ recorded maximum plant height (295 cm) which was significantly superior to other interactions of varieties vs spacings vs thinning. Whereas least plant height was observed in $V_1S_3T_4$ (200 cm). The values of other interaction effects were in between these two high values during 75th day after sowing (Table 2c).

Plant densities, thinnings, interactions of varieties vs spacings, varieties vs thinnings and spacings vs thinnings were not significant in respect of plant height at all stages of crop growth.

4.3 DRYMATTTER PRODUCTION PER PLANT

The data on drymatter production per plant in various treatments presented in Table 3a, b, c, d and e and depicted in Fig. 1,2 and 3. In general, there was an increase in dry weight, right from the beginning to harvest as evident from the mean values of all the treatments. The drymatter production per plant was 12 g by first month itself. The rate of drymatter production was about 85 g during second month, 95 g during 3rd month, 99 g during fourth month and 66 g after 120 days to harvest were added. Thus, the rate of drymatter

Table 3a Effect of varieties, spacings and thinning treatments on dry matter production (g) at different stages of crop growth

Treatments		Days after sowing				
		30	60	90	120	At harvest
	Varieties					
V_1	Ganga-5	11.97	96.74	196.22	289.70	351.[illegible]
V_2	DHM-103	12.44	89.94	169.60	274.18	[illegible]
V_3	African tall	12.32	108.30	214.03	312.70	[illegible]
	SE ±	0.74	7.59	6.47	4.62	4.9[illegible]
	CD at 5%	--	--	14.93	10.67	11.4[illegible]
	Spacings					
S_1	60 x 25 cm	12.29	94.50	206.73	321.55	[illegible]
S_2	45 x 15 cm	11.82	104.40	193.87	290.27	[illegible]
S_3	30 x 15 cm	12.62	94.86	179.27	264.76	[illegible]
	SE ±	0.74	7.59	6.47	4.62	4.95
	CD at 5%	--	--	14.93	10.67	11.40
	Thinnings					
T_1	Control (No thinning)	12.41	105.50	195.61	278.13	352.14
T_2	Thinning at 30 DAS	12.61	96.60	186.8[illegible]	290.67	359.3[illegible]
T_3	Thinning at 45 DAS	12.49	85.60	198.50	298.35	358.47
T_4	Thinning at 60 DAS	12.33	101.56	198.31	301.82	358.44
T_5	Thinning at 75 DAS	11.37	100.20	187.18	291.9[illegible]	360.89
	SE ±	1.15	3.36	6.48	5.89	6.36
	CD at 5%	--	5.80	--	--	--

Table 3b Effect of varieties x spacings (V x S) interaction on dry matter production per plant at different stages of crop growth

Varieties		90 DAS			120 DAS			At harvest		
		S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
V_1	Ganga-5	238.0	189.4	161.2	333.5	276.4	259.2	373.5	349.0	330.5
V_2	DHM-103	157.3	182.6	168.8	288.3	294.0	240.2	372.9	345.2	320.9
V_3	African tall	224.8	209.6	207.7	342.8	300.4	294.9	401.1	374.5	353.3
	SE $\pm$			11.2			8.0			8.6
	CD at 5%			25.9			18.5			19.8

Table 3c Effect of varieties x thinnings (V x T) interaction on dry matter production per plant at different stages of crop growth

Thinning treatment	60 DAS			90 DAS			120 DAS			At harvest		
	V_1	V_2	V_3	V_1	V_2	V_3	V_1	V_2	V_3	V_1	V_2	V_3
T_1	100.0	92.9	123.7	205.7	183.0	198.0	289.4	248.1	297.0	341.6	337.6	377.1
T_2	97.9	94.0	97.7	198.0	158.6	203.8	293.8	261.5	316.6	363.6	343.6	371.1
T_3	87.7	77.2	98.6	214.3	155.0	226.1	307.2	284.3	303.5	355.5	352.1	369.6
T_4	98.8	97.8	108.0	183.5	176.9	234.5	276.2	297.3	331.8	347.1	349.3	378.8
T_5	99.1	87.7	113.8	179.5	174.3	207.6	281.7	279.6	314.5	349.0	349.0	384.6
SE $\pm$			5.8			11.2			10.0			11.0
CD at 5%			11.8			2.8			20.7			22.4

Table 3d Effect of spacings x thinning (S x T) interaction on dry matter production per plant at different stages of crop growth

Thinning treatments	90 DAS			120 DAS			At harvest		
	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
T_1	221.1	194.3	171.3	306.1	289.5	238.8	372.1	356.3	328.0
T_2	188.8	180.1	191.5	313.6	285.8	272.5	373.6	356.6	348.1
T_3	239.8	191.5	164.1	347.4	286.4	261.1	401.0	353.0	321.3
T_4	189.4	210.5	194.9	337.7	293.2	274.5	394.5	350.3	330.5
T_5	194.3	192.8	174.3	302.7	296.2	275.8	371.1	364.8	346.6
SE $\pm$			11.2			10.0			11.0
CD at 5%			22.8			20.7			22.4

T1 = Control No thinning T2 = Thinning at 30 DAS T3 = Thinning at 45 DAS
T4 = Thinning at 60 DAS T5 = Thinning at 75 DAS DAS = Days After Sowing
S1 = 60 x 25 cm (66,666 plants/ha) S3 = 30 x 15 cm (2,22,222 plants/ha)
S2 = 45 x 15 cm (1,48,148 plants/ha)

Table 3e Effect of vareities x spacing x thinnings (V x S x T) on dry matter production per plant at different stages of crop growth

VxSxT	60 DAS					90 DAS					120 DAS					At harvest				
	T_1	T_2	T_3	T_4	T_5	T_1	T_2	T_3	T_4	T_5	T_1	T_2	T_3	T_4	T_5	T_1	T_2	T_3	T_4	T_5
V_1 S_1	92.3	73.2	75.0	78.3	81.2	246.2	214.5	312.5	201.0	216.0	326.5	334.0	396.0	319.7	291.2	352.0	382.0	407.0	388.0	338.5
S_2	130.0	120.1	110.2	130.5	115.2	229.0	172.0	193.5	177.0	175.5	287.7	260.0	285.7	256.6	291.9	347.5	344.0	333.0	334.0	386.5
S_3	77.7	100.5	77.9	87.6	100.7	142.0	207.5	137.0	172.5	147.1	254.0	287.5	240.0	252.5	262.0	325.5	365.0	320.5	319.5	322.0
V_2 S_1	94.2	95.0	78.0	101.1	69.0	209.2	137.5	133.0	152.9	154.0	285.0	277.0	306.2	295.0	278.5	357.0	365.0	390.0	379.5	373.0
S_2	87.0	114.0	80.0	92.2	96.0	163.0	175.5	182.0	194.5	198.0	290.5	281.5	283.7	317.5	296.8	337.0	355.0	359.0	348.0	327.0
S_3	97.5	73.0	73.7	99.5	98.0	177.0	163.0	150.0	183.4	171.0	168.8	226.0	263.0	279.5	263.5	319.0	311.0	307.5	320.5	347.0
V_3 S_1	136.0	109.0	97.7	107.0	130.0	208.0	214.5	274.0	214.5	213.0	307.0	330.0	340.0	398.5	338.5	407.3	374.0	406.0	416.0	402.0
S_2	113.5	84.3	94.0	114.0	104.0	191.0	193.0	199.0	260.0	205.0	290.5	316.0	290.0	305.5	300.0	384.5	371.0	367.0	369.0	381.0
S_3	121.5	100.0	104.0	103.0	107.5	195.0	204.0	205.5	229.0	205.0	293.5	304.0	280.5	291.5	305.0	339.5	368.5	336.0	351.5	371.0
SE $\pm$					10.1					19.4					17.7					19.1
CD at 5%					20.5					39.5					35.9					38.7

V1 = Ganga-5
V2 = DHN-103
V3 = African tall

S1 = 60 x 25 cm (66,666 plants/ha)
S2 = 45 x 15 cm (1,48,148 plants/ha)
S3 = 30 x 15 cm (2,22,222 plants/ha)

T1 = Control No thinning
T2 = Thinning at 30 DAS
T3 = Thinning at 45 DAS

T4 = Thinning at 60 DAS
T5 = Thinning at 75 DAS
DAS = Days After Sowing

Fig. 1 Effect of varieties on dry matter production per plant (g) at different stages of crop growth

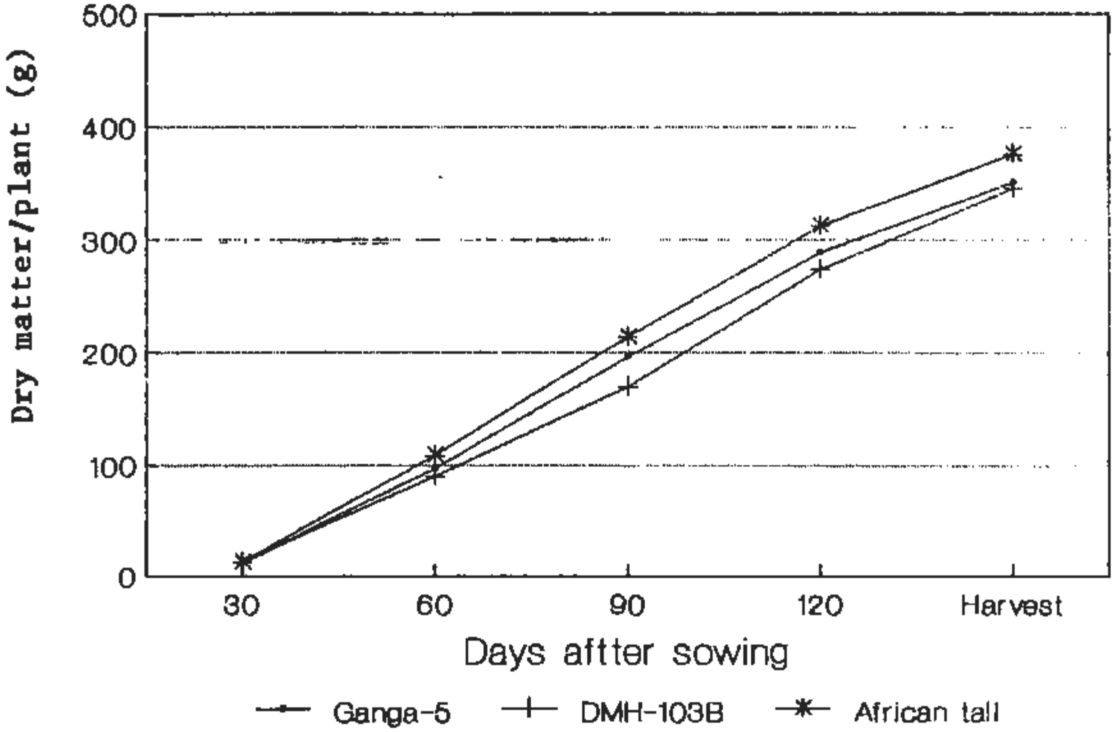


Fig. 2 Effect of spacings on dry matter production per plant (g) at different stages of crop growth

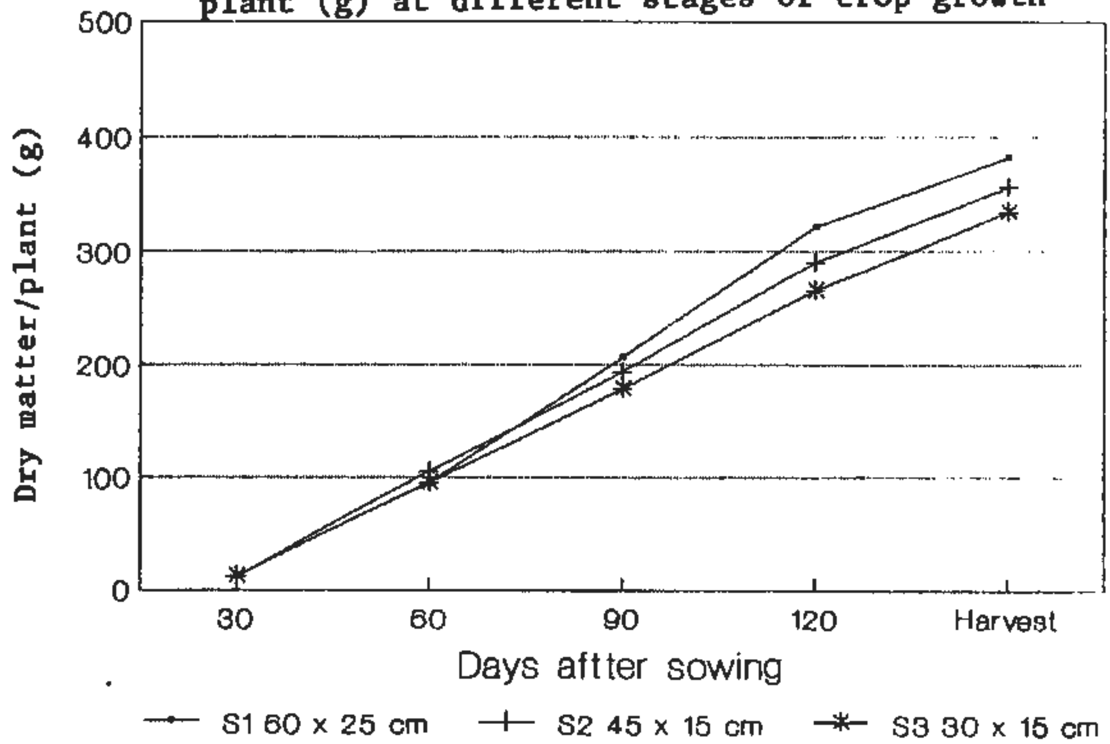
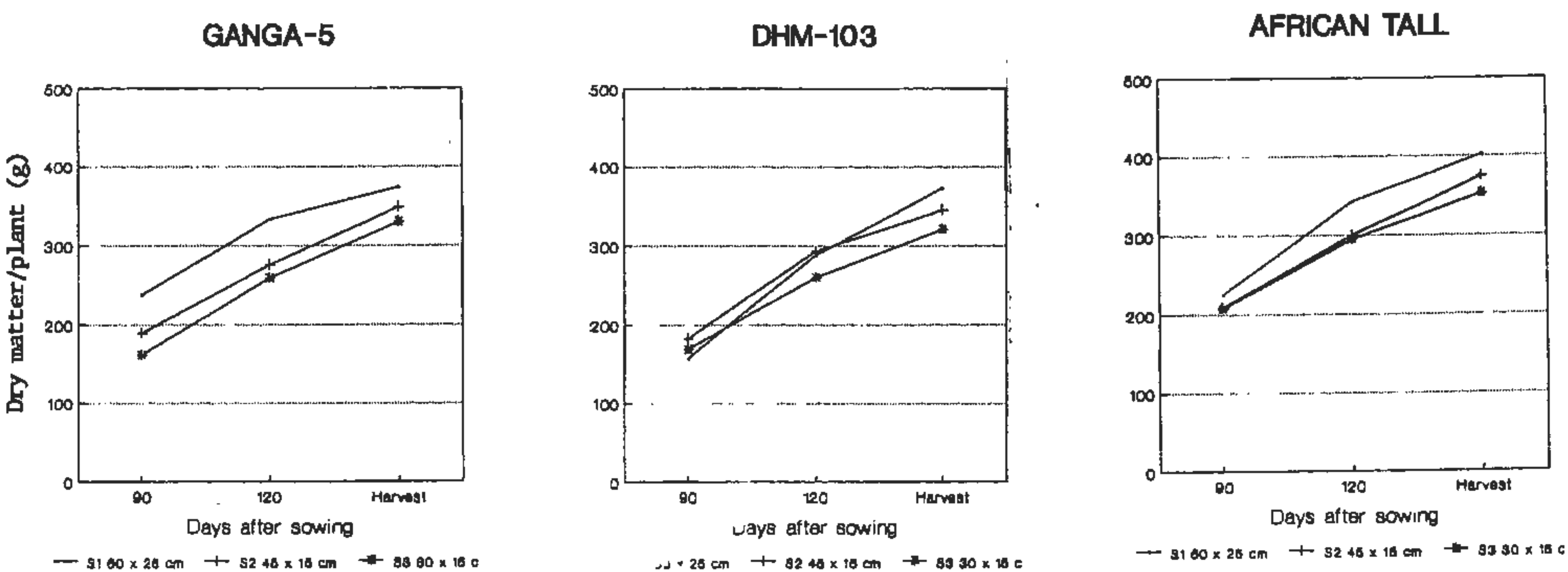


Fig. 3 Effect of varieties x spacing (V x S) interaction on dry matter production per plant at different stages of crop growth



accumulation was maximum during 3rd and 4th month after sowing and it coincided with peak tasseling/silking and grain developmental stages, respectively.

Drymatter production per plant increased with advancement of crop age in all varieties. The rate of drymatter accumulated from 30 to 60, 60-90, 90 to 120 DAS to harvest was 85 g, 99 g, 86 g and 61 g with Ganga-5; 78 g, 80 g, 105 g and 72 g with DHM-103; 96 g, 106 g, 99 g, and 63 g with African tall, respectively. Thus, the rate of drymatter accumulation was maximum during 3rd and 4th month after sowing in all these three varieties of maize. African tall recorded more dryweight over Ganga-5 and DHM-103 was 18 and 44 g at 90 DAS,45 g and 18 g at 120 DAS and 25g and 30 g at harvest respectively. Differences between varieties in respect of drymatter were found to be significant at 90 DAS and 120 DAS and harvest, whereas during 30 and 60 DAS, such significant differences wre not observed. African tall produced maximum dryweight which was significantly superior to Ganga-5 and DHM-103 at 90 and 120 DAs and later. At harvest, maximum dry weight of 376 g was recorded by African tall followed by Ganga-5 with 351 g and DHM-103 with 346 g.

There was significant increase in drymatter per plant with increase in widening the spacing from 30 x 15 cm (S_3), to 45 x 15 cm (S_2), to 60 x 25 cm (S_1) at 90, 120 days after sowing and also at harvest. The difference between normal population (S_1) and highest population level (S_3) at various stages was 27 g by 90th day, 57 g by 120th day, 48 g at harvet. The differntial values of drymatter production recorded by S_2 were inbetween the two extreme treatments. Thus the magnitude of drymatter production progressively increased with age of the crop at all population levels. Such increase of drymatter reached to maximum during 120 DAS and at harvest.

At the time of harvest, the plants grown under wider spacing S_1 (normal population level) produced higher drymatter (383 g) per plant as compared to S_2 (356 g) and S_3 (335 g). The per cent reduction in drymatter production over low plant density of S_1 was 6.81 with S_2 and 12.53 with S_3.

Thinning treatments i.e., T_2 to T_5 produced almost equal drymatter to the control (T_1) during last two stages of crop growth (120 DAS and harvest) and their differences were not significant at 90, 120 DAS and at harvest.

The interaction of varieties x spacings was significant at 90, 120 DAS and at harvest (Table 3b and Fig 3). In Ganga-5 and African tall, plants grown under wider spacing (60 x 25 cm) attained maximum dry weight per plant followed by closer spacings of S_2 (45 x 15 cm) and S_3 (30 x 15 cm) during last three stages of crop growth. While in DHM-103, spacing of 45 x 15 cm recorded higher drymatter over wider spacing i.e., 60 x 25 cm (S_1) as well as closer spacing of 30 x 15 cm (S_3) at 90 and 120 DAS, whereas during harvest its trend was reversed. During this stages, plants of DHM-103 grown under wider spacing (S_1) recorded maximum dryweight (372 g) which was significantly superior to S_2 (345 g) and S_3 (321 g).

The interaction of varieties and thinning treatments were found to be significant at 60 DAS to harvest (Table 3c). However, such interaction effects were different at different stages of crop grwoth. The interaction effect of African tall with thinning tratments were significantly superior in production of dry matter per plant as compared to other interaction effects of Ganga-5 or DHM-103 with thinning treatments at all stages of crop growth (60 DAS to harvest). At 60 DAS, plants of Ganga-5 grown under control plots (without thinning) recorded significantly more drymatter (100 g) than T_3 (87 g) and it was on par with T_2 (98 g), T_4 (99 g), T_5 (99 g) treatments. During 90 DAS under this variety, there was a significantly lower production of dry weight per plant observed with thinning treatments of T_5 (180 g), T_4 (183 g) when compared to control T_1 (206 g) while T_3 produced more drymatter (214 g) when compared with T_2 (198 g), T_4 (184 g) and T_5 (180 g) and it was on par with control (206 g). Similarly at 120 DAS reduced plant dry weight was observed with T_4 (276 g) compared with T_3 (307 g).However all thinning treatments were on par with control with variety of Ganga-5. At the time of harvest thinned plants of T_2 (364 g) produced significantly more dry weight over (342 g) as well as remaining treatments of T_3 (353 g), T_4 (347 g) and T_5 (349 g) under variety Ganga-5.

In DHM-103, there was a significant reduction of plant dry weight with thinning treatment of T_3 (77 g) as compared with control T_1 (93 g during 60 DAS). While the remaining treatments were on par with control during this stage. Similarly during 90 DAS, thinned plants of T_2 (159 g), T_3 (155 g), T_4 (177 g) and T_5 (174 g) recorded lesser drymatter production compared with control T_1 (183 g). While at 120 DAS, control (T_1 i.e., without thinning) plot recorded (248 g) significantly lesser drymatter as compared to T_3 (284 g), T_4 (297 g) and remaining thinning treatments were on par with control. At harvest, thinning treatments had no impact on drymatter production in this variety.

In African tall, plants grown under control plot (T_1) obtained maximum dry weight per plant (124 g) and it was superior to thinning treatments of T_5 (114 g), T_4 (108 g), T_3 (99 g) and T_2 (98 g) during 60 DAS. Whereas at 90 DAS, T_4 produced higher drymatter when comapred to control as well as remaining thinning treatments of T_2, T_3 and T_5. Similarly at 120 DAS, T_4 produced (332 g)more drymatter over control (297 g). During harvest, thinning had no significnat impact on dry matter production and produced almost equal drymatter with control.

The interaction of plant densities x thinning reatments significantly differed in dry weight of plant at 90 DAS, 120 DAS and harvest only, whereas at 30 and 60 DAS the differences were not significant in respect of drymatter production per plant (Table 3d). Irrespective of thinning treatments, plants grown under wider spacing of 60 x 25 cm (S_1) attained more drymatter as comapred to closer spacings of 45 x 15 cm (S_2) and 30 x 15 cm (S_3) at 90 DAS, 120 DAS and harvest.

During 90 DAS, there was a significant reduction of drymatter over control in the order of 32.4 g; 31.7 g and 26.9 g with thinning treatments of T_2, T_4 and T_5, respectively under low plant density level (S_1) while T_3 obtained dryweight which was on par with control (T_1). whereas during 120 DAS, earlier thinning treatment T_3 recorded significantly higer drymatter (347 g) compared to control (307 g) under given plant spacing of S_1. During harvest, thinning treatments of T_3 and T_4 produced significantly higher drymatter (401 and 394 g) as comapred to control T_1 (372 g) under the plant spacing of S_1.

Thinning had no impact on drymatter production of plant under closer spacings of S_2 and S_3 during 90 DAS. Under S_3 population level (2,22,222 plants ha^{-1}), there was a signficiant increase in dryweight with thinning treatments of T_2 (273 g), T_3 (286 g), T_4 (293 g) and T_5 (276 g) when compared with control (239 g) during 120 DAS. Maximum dry weight was observed with T_2 (272 g) which was significantly superior to remaining thinning treatments at this stage (120 DAS). Whereas under S_2 population level at 120 DAS, drymatter production was almost equal between control and thinning treatments of T_2, T_4 and T_5.

The interaction effect of S_1T_3 (239 g and 347 g and 401 g respectively) at 90, 120 DAS and harvest recorded maximum dry weight. Whereas least dry weight was observed with S_3T_3 (164 g) at 90 DAS, with S_2T_3 (261 g) at 120 DAS and S_3T_3(321 g) at harvest. The values of remaining interaction effects of spacings x thinnings were in between these values at their corresponding stages.

Thus the thinning treatments increased dry weight over control at 120 DAS and harvet. Such increase of dry weight over control was more pronounced under wider spacings (low population levels) as compared to closer spacings (higher population level).

The interaction treatment of $V_1S_1T_3$ had maximum drymatter during 90 DAS, 120 DAS and harvest whereas least drymatter was observed in $V_2S_3T_2$ (Table 3e).

4.4 NUMBER OF DAYS FOR 50 PER CENT TASSELING

DHM-103 took significantly lesser number of days (67 days) for 50% tasseling indicating its earlyness compared to Ganga-5 which tasseled by 69 days and African tall by 78 days. The differences between spacings, thinnings and interaction effect between varieteis vs spacings, varieteis vs thinnings, spacings vs thinnings, varieties vs spacings, spacing vs thinnings were not significant in respect of number of days for 50% tasseling (Table 4).

4.5 NUMBER OF DAYS FOR 50 PER CENT SILKING

There was a signficiant variation for number of days to 50% silking between varieties. Ganga-5 (70 days) and DHM-103 (71 days) took lesser number of days for 50% silking as compared to African tall (81 days). However the differnces between spacings, thinnings, interaction effects of varieteis vs spacings, varieteis vs thinnings, spacings vs thinnings, varieteis vs spacings vs thinnings were not found significant in respect of days to 50% silking (Table 4).

Table 4 Effect of varieties, spacings and thinning treatment on days to 50 per cent tasseling and silking

Treatments		Duration for Tasseling	Duration for silking
	Varieties		
V_1	Ganga-5	68.60	71.60
V_2	DHM-103	67.43	70.40
V_3	Africantall	78.17	80.87
	SE $\pm$	0.32	0.60
	CD at 5%	0.74	0.93
	Spacings		
S_1	60 x 25 cm	71.23	74.27
S_2	45 x 15 cm	71.23	74.10
S_3	30 x 15 cm	71.57	74.50
	SE $\pm$	0.32	0.60
	CD at 5%	--	--
	Thinning treatments		
T_1	Control (No thinning)	71.22	74.17
T_2	Thinning at 30 DAS	71.61	74.67
T_3	Thinning at 45 DAS	71.17	74.33
T_4	Thinning at 60 DAS	71.39	74.17
T_5	Thinning at 75 DAS	71.33	74.11
	SE $\pm$	0.29	0.66
	CD at 5%	--	--

4.6 YIELD COMPONENTS AND YIELD

Number of cobs per plant, cob weight, number of grains per cob and 100 seed weight were collected at harvest and presented in Table 5a, 5b and 5c.

4.6.1 Number of Cobs Per Plant

Variety DHM-103 recorded maximum number of cobs per plant (1.101) which was on par with Ganga-5 (1.057) and significantly superior to African tall (0.814).

Plants grown under wider spacing (60 x 25 cm) recorded significantly more number of cobs per plant (1.160) as compared with closer spacings of 45 x 15 cm (0.940) and 30 x 15 cm (0.892). The per cent decrease in cob number over wider spacing (S_1) was 18.96 and 21.82 with closer spacing of S_2 (45 x 15 cm) and S_3 (30 x 15 cm) respectively. Thus there was a decrease in cob number with incrase in plant density.

Plants grown under control plot (T_1) recorded significantly lesser number of cobs per plant (0.62) than under thinning treatments of T_2 (1.071), T_3 (1.086) T_4 (1.101) and T_5 (1.076). The per cent increase in cob number over control was 72.74; 75.16; 77.58; 73.55 with thinning treatments of T_2, T_3, T_4 and T_5 respectively.

4.6.2 Cob Wegiht (g)

'African tall' had signficiantly lower cob weight (156 g) as compared to Ganga-5 (168 g) and DHM-103

Table 5. Effect of varieties, spacings and thinning treatments on yield components

	Treatments	No. of cobs/ plant	Cob weight (g)	No. of grains/ cob	100 seed weight (g)
	Varieties				
V_1	Ganga-5	1.057	168.130	517.830	25.720
V_2	DHM-103	1.101	166.490	511.930	26.170
V_3	Africantall	0.814	156.390	509.700	24.720
	SE ±	0.608	4.018	2.011	0.914
	CD at 5%	0.047	9.270	4.630	--
	Spacings				
S_1	60 x 25 cm	1.160	173.700	514.830	26.900
S_2	45 x 15 cm	0.940	162.690	511.100	25.640
S_3	30 x 15 cm	0.872	154.630	513.530	24.070
	SE ±	0.608	4.018	2.011	0.914
	CD at 5%	0.047	9.270	--	2.110
	Thinning treatments				
T_1	Control (No thinning)	0.620	164.940	512.110	26.160
T_2	Thinning at 30 DAS	1.071	159.370	515.280	25.010
T_3	Thinning at 45 DAS	1.086	165.140	514.390	25.650
T_4	Thinning at 60 DAS	1.101	162.530	512.940	25.230
T_5	Thinning at 75 DAS	1.076	166.400	511.050	25.630
	SE ±	0.666	2.927	1.832	0.627
	CD at 5%	0.027	--	--	--

Table 5b Effect of varieties x thinnings (V x T) and spacing x thinning treatment interactions on cob weight (g)

		V x T			S x T		
		V_1	V_2	V_3	S_1	S_2	S_3
T_1	Control No thinning	165.0	177.0	151.0	181.0	159.0	153.0
T_2	Thinning at 30 DAS	168.0	162.0	149.0	163.0	162.0	152.0
T_3	Thinning at 45 DAS	168.0	168.0	158.0	179.0	163.0	152.0
T_4	Thinning at 60 DAS	168.0	165.0	154.0	164.0	165.0	157.0
T_5	Thinning at 75 DAS	169.0	161.0	163.0	179.0	163.0	155.0
SE $\pm$				5.1			5.1
CD at 5%				10.3			10.3

V1 = Ganga-5 S1 = 60 x 25 cm (66,666 plants/ha)
V2 = DHM-103 S2 = 45 x 15 cm (1,48,148 plants/ha)
V3 = African tall S3 = 30 x 15 cm (2,22,222 plants/ha)
DAS = Days After Sowing

Table 5c Effect of varieties x spacings x thinnings (V x S x T) interactions on yield components

VxSxT	Cob weight (g)					No. of grains/cob					100 seed weight (g)				
	T_1	T_2	T_3	T_4	T_5	T_1	T_2	T_3	T_4	T_5	T_1	T_2	T_3	T_4	T_5
V_1 S_1	174.0	171.0	190.0	190.0	176.0	513.0	519.0	531.0	525.0	508.0	27.0	26.0	29.0	27.5	27.1
S_2	160.0	171.0	162.0	152.0	172.0	517.0	525.0	513.0	506.0	517.0	24.5	26.1	25.0	23.4	26.5
S_3	163.0	161.0	153.0	162.0	158.0	513.0	522.0	518.0	515.0	522.0	25.4	24.5	23.5	24.9	24.7
V_2 S_1	183.0	161.0	131.0	163.0	176.0	512.0	508.0	513.0	512.0	510.0	28.9	25.5	29.6	25.5	26.8
S_2	184.0	174.0	181.0	180.0	152.0	508.0	514.0	513.0	513.0	506.0	30.8	27.5	27.7	28.5	23.6
S_3	165.0	145.0	142.0	152.0	155.0	518.0	510.0	[illegible]	506.0	521.0	25.8	22.8	22.5	23.7	23.6
V_3 S_1	187.0	158.0	156.0	140.0	184.0	513.0	520.0	510.0	514.0	[illegible]	29.7	24.8	26.0	27.5	28.9
S_2	134.0	140.0	145.0	162.0	166.0	497.0	512.0	509.0	512.0	503.0	22.2	23.8	27.5	25.4	26.3
S_3	133.0	150.0	162.0	159.0	155.0	516.0	506.0	510.0	[illegible]	500.0	[illegible]	23.6	25.5	25.5	22.7
SE					8.8					5.5					1.9
CD at 5%					17.9					11.2					5.3

V1 - Ganga-5
V2 - VHM-103
V3 = African tall
S1 = 60 x 25 cm (66,666 plants/ha)
S2 = 45 x 15 cm (1,48,148 plants/ha)
S3 = 30 x 15 cm (2,22,222 plants/ha)

T1 = Control No thinning
T2 = Thinning at 30 DAS
T3 = Thinning at 45 DAS

T4 = Thinning at 60 DAS
T5 = Thinning at 75 DAS
DAS = Days After Sowing

(166 g). Plants grown under wider spacings of 60 x 25 cm (S_1) produced significantly bigger cobs (174 g), when compared with closer spacing of S_2 : 45 x 15 cm (163 g) and S_3 : 30 x 15 cm (154 g). Thinning had no significant impact on cob weight.

In Ganga-5, there was a slight increase in cob weight with thinning treatments of T_2 (168 g),T_3 (169 g), T_4(168 g) and T_5 (169 g), as compared to control (166 g). In African tall, thinning at 75 DAS (T_5) recorded more cob wegiht (169 g) as compared to control (152 g) and thinning treatment of T_2 (150 g), T_3 (158 g) and T_4 (154 g), whereas with DHM-103, there was a significant reduction of cob wegiht with thinning treatments of T_2 (160 g), T_3 (168 g), T_4 (165 g) and T_5 (161 g) compared to control (177 g). The interaction effect of Ganga-5 x thinning treatments of T_2, T_3, T_4, T_5 resulted in significantly more cob wegiht as compared to other interaction effect of DHM-103 x thinning treatments and African tall x thinning treatments. The interaction effect of V_2T_1 (177 g), V_3T_5 (169 g) recorded maximum cob weight whereas least vlaue was observed with V_3T_2 (149 g) treatment. The values of remaining interaction treatments were placed in between these two extreme values.

Irrespective of thinning treatments, plants grown under wider spacing recorded significantly more cob weight as compared to closer spacings. Under low plant density, there was a signficant reduction of cob wegiht with T_2 (163 g) T_4 (165 g) as compared to control (182 g) while in closer spacings of S_2 and S_3, such thinning treatments increased cob wegiht marginally over control. The interaction effect of $V_1S_1T_3$ and $V_1S_1T_4$ helped to recorded maximum cob weight (191 g each), whereas least cob weight was observed in $V_3S_3T_1$ (133 g). The values of remaining interaction effects varied between these two end values.

4.6.3 Number of Grains per Cob

The data on number of grains per cob was recorded at the time of harvest and presented in Table 5a and 5c. Ganga-5 possessed significantly more number of grains per cob (518) over DHM-103 (512) and African Tall (510). The interaction treatment of $V_1S_1T_3$ recorded maximum no. of grains per cob (531) whereas least number of grains per cob were observed with $V_3S_3T_5$ (500). The values of remaining interaction treatment were in betwen these two values. The differences between spacings, thinnings, interaction effects between varieteis vs thinning; vaieteis vs spacings; spacings vs thinnings were not significant in respect of number of grains per cob.

4.6.4 100 Seed Weight

The differences between varieties, spacings, thinning and their interactions were not significant in respect of 100 seed weight. However, plants grown under wider spacings of S_1 and S_2 recorded significantly more 100 seed weight of 26.9 g and 25.6 g, respectively over closer spacing of S_3 (24.07 g). $V_1S_1T_3$ recorded maximum 100 seed weight of 29.1 g while least 100 seed weight was observed with $V_3S_3T_1$ (21.8 g). The values of remaining treatments were in between these two values.

4.7 YIELD

4.7.1 Grain Yield (Quintals per hectare)

The grain yield particulars in q ha^{-1} are given in Table 6a, 6b and shown in Fig. 4, 5, 6 and 7. The grain yield differed significantly among varieties and different population levels. The interaction between varieties and populations, were also found to be significant.

Ganga-5 recorded the maximum grain yield of 44.35 q ha^{-1} which was significantly superior to DHM-103 (41.90 q ha^{-1}) and African tall (28.94 q ha^{-1}).

Grain yield significantly increased with increase of plant density from S_1 : 66,666 plants ha^{-1} (33.85 q ha^{-1}) to S_2 : 1,48,148 plants ha^{-1} (38.77 q ha^{-1}) and S_3 : 2,22,222 plants ha^{-1} (42.57 q ha^{-1}). The seed rates caused signficant improvement in grain yield. Highest seed rate helped in realising significantly higher grain yield compared to lower seed rates (S_2 and S_1) inturn S_2 yields were also significantly superior to

Table 6: Effect of varieties, spacings and thinning treatments on grain, stover and forage yield (Quintals/hectare)

Treatments		Grain yield	Stover yield	Forage yield
	Varieties			
V_1	Ganga-5	44.35	72.99	84.80
V_2	DHM-103	41.90	69.13	85.52
V_3	Africantall	28.94	125.68	97.04
	SE ±	1.27	6.96	1.01
	CD at 5%	2.93	16.08	--
	Spacings			
S_1	60 x 25 cm	33.85	74.82	76.13
S_2	45 x 15 cm	38.77	92.48	90.99
S_3	30 x 15 cm	42.57	101.15	100.25
	SE ±	1.27	6.96	1.01
	CD at 5%	2.93	16.08	2.29
	Thinning treatments			
T_1	Control (No thinning)	39.12	90.01	2.16
T_2	Thinning at 30 DAS	37.64	86.18	4.11
T_3	Thinning at 45 DAS	38.16	89.57	13.82
T_4	Thinning at 60 DAS	37.55	89.85	36.94
T_5	Thinning at 75 DAS	39.50	91.68	47.56
T_6	(Entire plot harvested as forage at 75 DAS)	--	--	430.34
	SE ±	1.96	5.59	1.76
	CD at 5%	--	--	2.59

Table 6b Effect of varieties x spacings (V x S) interaction on grain and stover yield

	Grain yield (q/ha)			Stover yield (q/ha)		
	S_1	S_2	S_3	S_1	S_2	S_3
V_1 Ganga-5	40.96	44.62	47.46	64.03	74.92	80.02
V_2 DHM-103	36.13	42.79	46.79	61.54	68.03	77.87
V_3 African tall	24.47	28.90	33.46	98.90	132.57	145.55
SE $\pm$			2.19			12.05
CD at 5%			5.06			27.87

Table 6c Effect of varieties x thinnings (V x T) on stover yield; spacings x thinnings (S x T) interactions on stover and forage yield (q/ha)

	V x T Stover yield (q/ha)			S x T Stover yield (q/ha)			S x T Forage yield (q/ha)		
	V_1	V_2	V_3	S_1	S_2	S_3	S_1	S_2	S_3
T_1	73.59	73.09	123.38	73.12	92.24	104.39	2.16	2.16	2.16
T_2	70.76	65.44	122.38	79.25	85.41	93.90	2.90	3.88	5.54
T_3	80.25	68.59	116.88	76.75	94.07	97.90	9.82	14.93	16.71
T_4	72.93	69.93	126.71	67.10	94.57	107.89	31.63	37.79	41.40
T_5	67.43	68.59	139.03	77.58	95.90	101.56	42.84	46.67	53.17
T_6	--	--	--	--	--	--	367.41	440.50	482.52
SE $\pm$			9.69			9.69			2.19
CD at 5%			19.71			19.71			4.49

V1 = Ganga-5
V2 = DHM-103
V3 = African tall
S1 = 60 x 25 cm (66,666 plants/ha)
S2 = 45 x 15 cm (1,48,148 plants/ha)
S3 = 30 x 15 cm (2,22,222 plants/ha)

T1 = Control No thinning
T2 = Thinning at 30 DAS
T3 = Thinning at 45 DAS
T4 = Thinning at 60 DAS
T5 = Thinning at 75 DAS
T6 = Entire plot harvest as forage at 75 DAS
DAS = Days After Sowing

Fig. 4 Effect of varieties on grain, stover and forage yield (Quintals/Hectare)

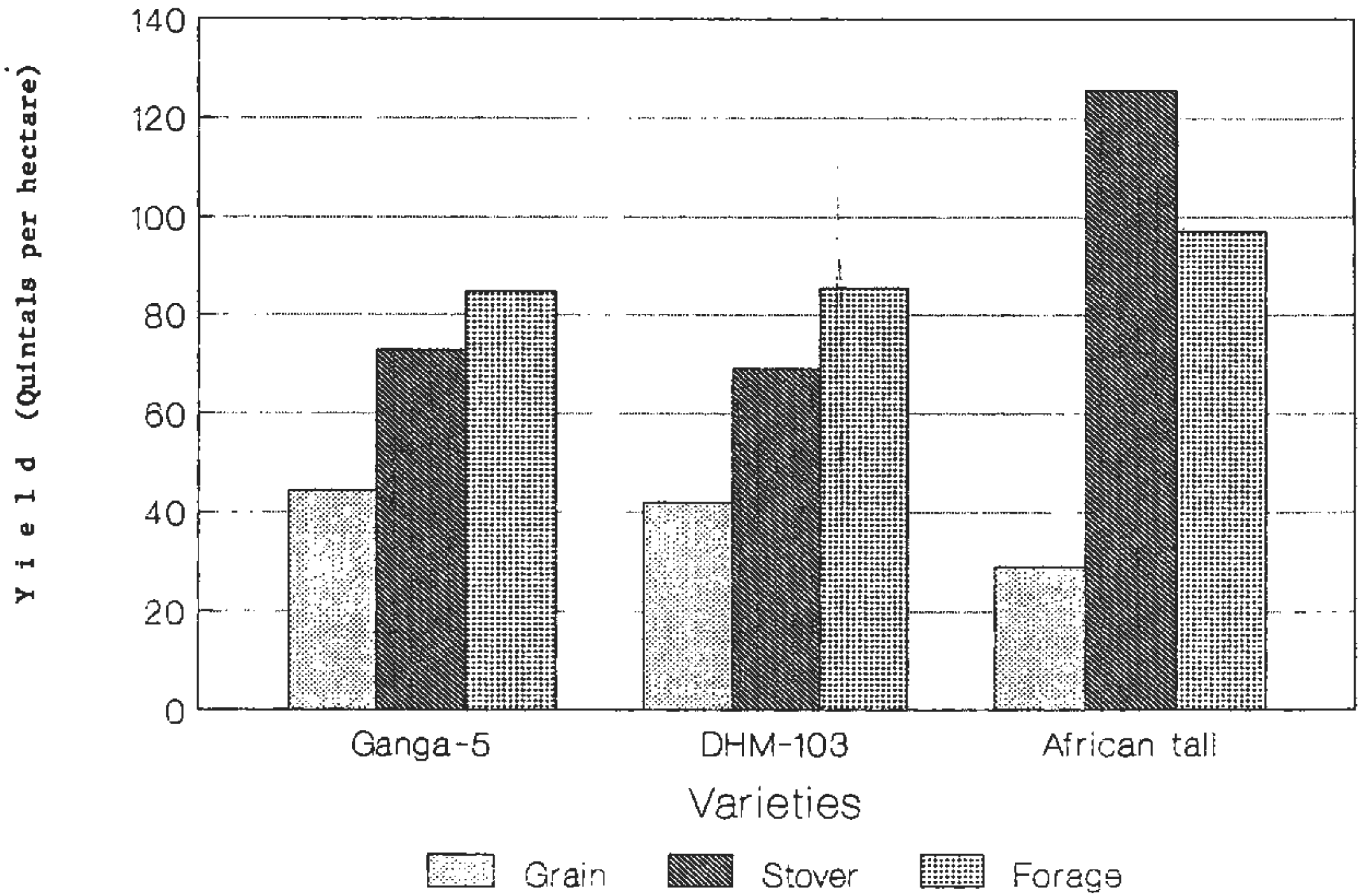


Fig. 5 Effect of spacings on grain, stover and forage yield (Quintals/Hectare)

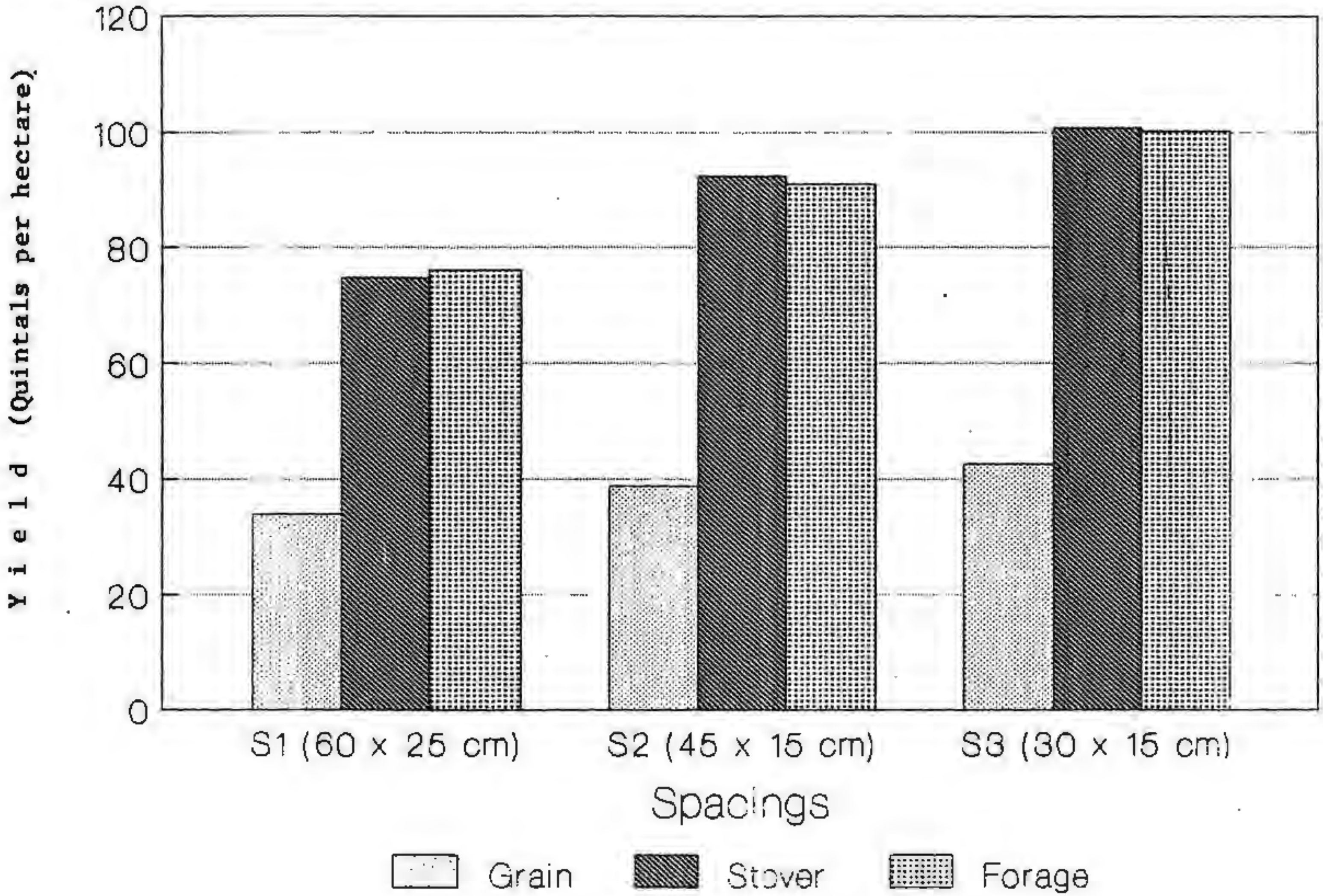


FIG. 6 EFFECT OF THINNING TREATMENTS ON GRAIN, STOVER AND FORAGE YIELD (Quintals per hectare)

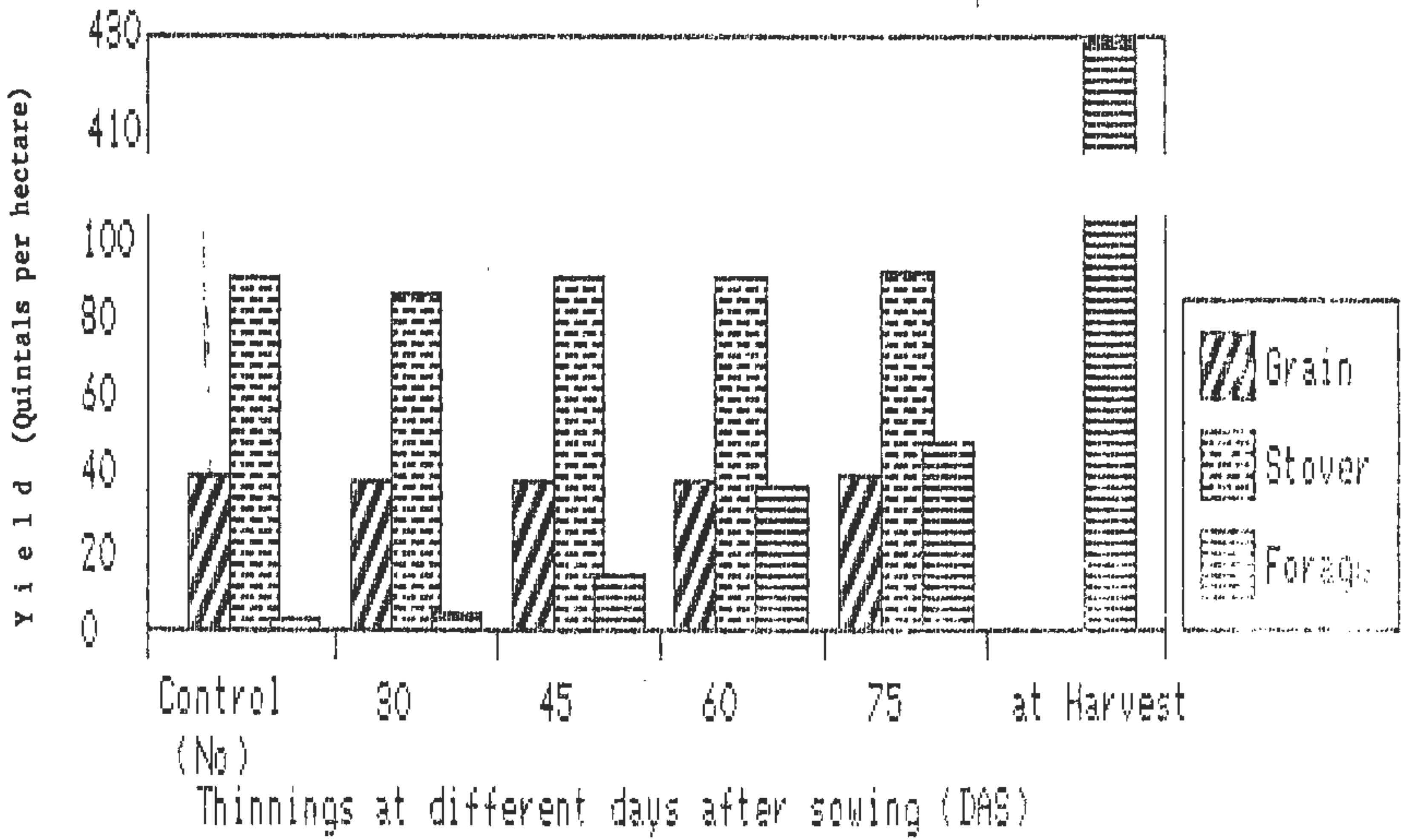
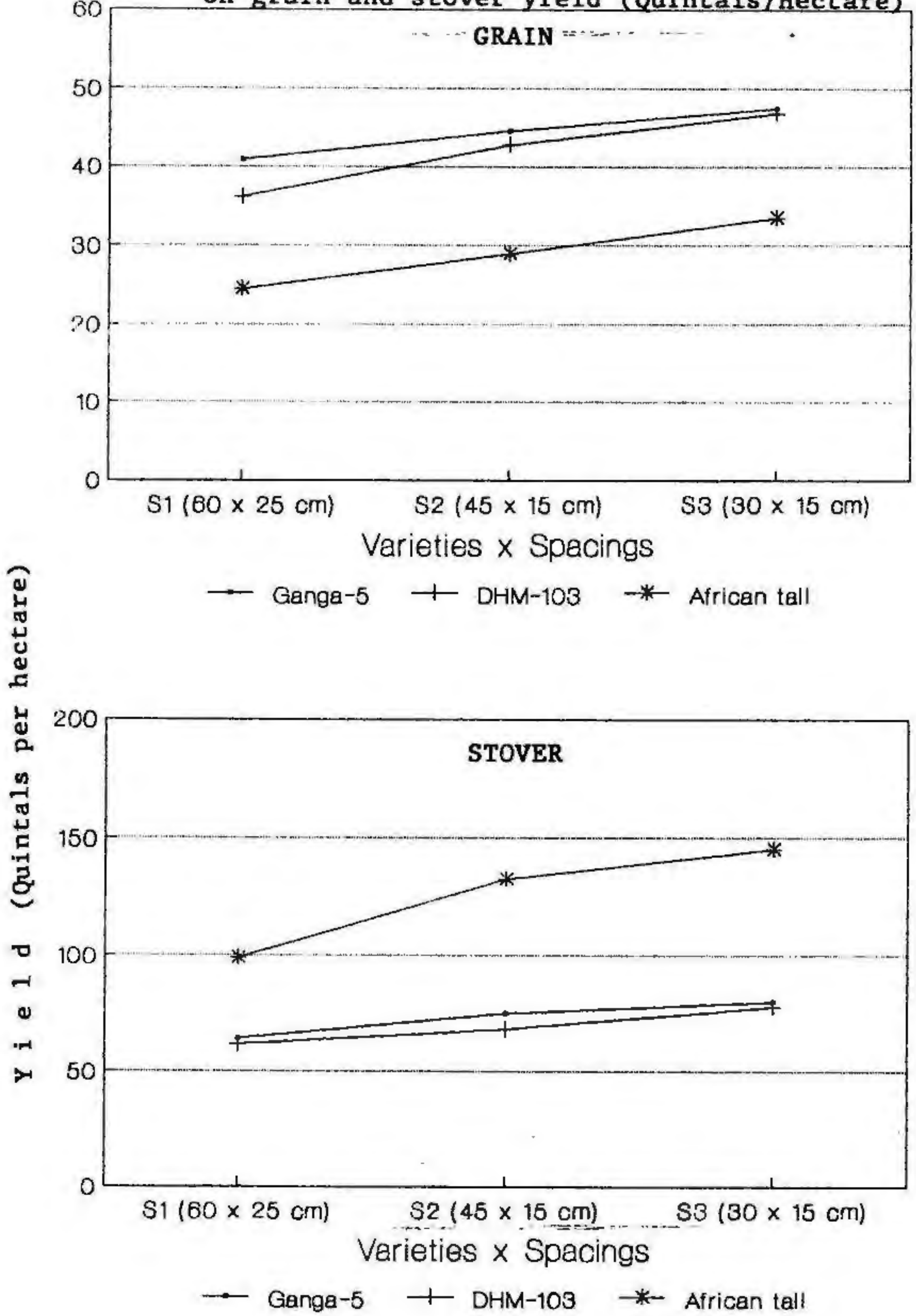


Fig. 7 Effect of varieties x spacing (V x S) interaction on grain and stover yield (Quintals/Hectare)



S_1 yield. The per cent increase in grain yield with highest population of S_3 over S_1 was 20.48 per cent and over S_2 was 8.93 per cent. Thus there was increase in grain yield as increased plant density from 66,666 to 2,22,222 plants ha^{-1}. Thinning treatmental differences failed to alter grain yield.

For the given maize varieties, change in population from S_1 to S_3 showed progressive increase in grain yield. Such increase in grain yield with plant density was more pronounced in DHM-103 as compared to African tall and Ganga-5. In case of DHM-103 significant increase in grain yield with change of seed rate from S_1 to S_2 or from S_1 to S_3 was observed while change from S_2 to S_3 differences were not significant. The yield improvement in DHM 103 was as high as 6.66 q ha^{-1} (13.4%) and 10.66 q ha^{-1} (29.5%) from S_1 to S_2 and S_1 to S_3. In 'African tall' a significant improvement of 4.43 q ha^{-1} (18.10%) and 8.99 q ha^{-1} (36.7%) in grain yield was realised with change of seed rate from S_1 to S_2 and S_1 to S_3 in seed rate. The improvement was of 3.66 q ha^{-1} (8.9%) and 6.5 q ha^{-1} (15.9%) in case of Ganga-5 with increase in seed rates from S_1 to S_2 and S_1 to S_3. V_1S_3 recorded maximum grain yield of 47.46 q ha^{-1} while minimum yield of 24.47 q ha^{-1} was observed in V_3S_1. The values of remaining treatments fell in between these two ends. The interaction effect between varieties vs thinnings; spacings vs thinning levels; varieties vs spacings vs thinning were not found significant in respect of grain yield.

4.7.2 Stover Yield

The drymatter of the plant at harvest after removing the cobs was recorded as stover yield in q ha^{-1}. The data are given in Table 6a, b. The stover yield differences were significantly influenced by varieties and spacings. Among the interactions, varieties vs spacings; varieties vs thinnings; spacings vs thinning were found to be a significant while varieties vs spacings vs thinnings failed to do the same.

Stover yield was as high as 125.68 q ha^{-1} in African tall which was significantly superior to the production of Ganga-5 (72.99 q ha^{-1}) and DHM-103 (69.13 q ha^{-1}).

High plant density in 30 x 15 cm gave the highest stover yield of 101 q ha^{-1}. Stover yield significantly increased with decrease of spacing for individual plants from 60 x 25 cm (75 q ha^{-1}) to 45 x 15 cm (93 q ha^{-1}) and 30 x 15 cm (101 q ha^{-1}). Closer spacing of 30 x 15 cm resulted in superior production of stover by 23.60 per cent over 45 x 15 cm and 34.80 per cent over 60 x 25 cm spacings.

The stover yield differences due to thinnings were not significant. Stover yield increased with decreasing of spacing for individual plants from 60 x 25 cm to 45 x 15 cm and 30 x 15 cm in all thinning plots. Such increase in stover yield with population was more in late thinning T_5 (at 75 DAS) as compared to earlier thinning of T_2 (30DAS), T_3 (45 DAS) and T_4 (60 DAS).

In all varieties, there was a progressive improvement in stover yield with increase of plant density in the spacings from S_1 to S_3. Significantly superior stover yield was recorded in African tall in S_3 over S_1. While the other varietal differences or improvements were statistically not significant. In Ganga-5 the thinnings treatmental differences were not significant in respect of stover yield. Similar was the trend observed in DHM-103.

In DHM-103, there was a significant reduction of stover yield with thinning treatments of T_2 (65.44 q ha^{-1}), T_3 (68.59 q ha^{-1}) and T_4 (69.93 q ha^{-1}) when compared with 'control' T_1 (73.09 q ha^{-1}). In African tall T_5 recorded significantly higher stover yield (139.03 q ha^{-1}) as compared to T_3 (116.8 q ha^{-1}) while T_2, T_4 and T_1 treatments were on par with T_5.

4.7.3 Forage Yield

The green fodder of plants harvested at the time of imposing the thinning treatments at 30 DAS (T_2), 45 DAS (T_3), 60 DAS (T_4), and 75 DAS (T_5) was recorded as forage yield (in q ha^{-1}). An additional treatment (T_6) was also grown as per the spacing treatments and harvested (entire plot) at 75 DAS. The grain yield was the only yield recorded in T_1 (control) which were not included in the analysis. On an average the forage that could be realised was substantial (more than 20 quintals per hectare). Depending upon the time of thinning the yield ranged between 2 q to 50 q forage per hectare. The differences in yield due to varieties were not significant (Table 6a and b).

Forage yield differences due to various spacings were statistically significant. Closest spacing of 30 x 15 cm resulted in significantly superior yield of 24.12 q ha^{-1} over normal spacing plots (60 x 25 cm). In turn the medium spacing of 45 x 15 cm also recorded significantly superior yield over the closer spacing treatment (17.66 q ha^{-1}). This shows a promise of putting higher seed rate at the time of sowing, which could be conviently brought down to the recommended (S_1) spacing population and in the process realise a substantial green fodder, during crop growth. The remaining plants which bear the cobs were harvested for grain without any significant reduction in grain yield.

The removal of plants at various stages of crop growth i.e., thinning treatments, resulted in the forage yield whose differences were statistically significant.

The plants harvested at 75 DAS for impositio. of thinning teatment (T_5) resulted in maximum green forage yield which was significantly superior to the rest. A definite reduced production of green fodder was observed with each reduction of period in thinning. In otherwords with each increase in period of available growth before thinning, resulted in significant, improvement in green fodder yield starting from 30 DAS, 45 DAS, 60 DAS and highest at 75 DAS.

For a given variety of maize, change in populations rate due to spacing from S_1 (60 x 25 cm) to S_2 (45 x 15 cm) and S_3 (30 x 15 cm) showed a progressive increase in forage yield. Such increase in forage yield was maximum in 'African tall' followed by DHM 103 and Ganga-5. Treatment V_3S_3 obtained maximum forage yield (117.26 q ha^{-1}) wheras least yield was recorded by V_1S_1 (75.84 q ha^{-1}) and V_2S_1 (76.90 q ha^{-1}).

4.8 MONETARY RETURNS

Monetary returns were calculated according price value of grain (Rs 150 q^{-1}); price value of stover (Rs 18 q^{-1}) and price value of forage (Rs 18 q^{-1}). Gross monetary returns is the cumulative returns of grain, stover and forage.

4.8.1 Monetary Returns On Grain Yield

Monetary returns due to grain yield were maximum with Ganga-5 (Rs 6,651) which was statistically on par

Table 7a Effect of varieties, spacings and thinning treatments on monetary returns for grain, stover, forage and gross returns (Rs)

	Treatments	Due to grain (Rs)	Due to stover (Rs)	Due to forage (Rs)	Gross returns (Rs)
	Varieties				
V_1	Ganga-5	6651.80	1313.82	1526.46	9492.08
V_2	DHM-103	6284.90	1244.34	1539.33	9068.57
V_3	Africantall	4341.80	2262.12	1745.69	8349.61
	SE $\pm$	191.31	287.30	1883.15	319.97
	CD at 5%	439.95	663.27	43.33	736.59
	Spacings				
S_1	60 x 25 cm	5077.81	1346.76	1370.28	7794.84
S_2	45 x 15 cm	5815.50	1664.64	1637.79	9117.93
S_3	30 x 15 cm	6385.20	1815.30	1804.49	10004.99
	SE $\pm$	191.31	287.30	1883.15	319.97
	CD at 5%	439.95	663.27	43.33	736.59
	Thinning treatments				
T_1	Control (No thinning)	5868.50	1620.18	38.88	7527.56
T_2	Thinning at 30 DAS	5646.50	1551.24	73.98	7271.72
T_3	Thinning at 45 DAS	5724.50	1607.40	248.76	7580.66
T_4	Thinning at 60 DAS	5633.00	1614.24	664.92	7912.16
T_5	Thinning at 75 DAS	5925.00	1650.24	856.08	8431.32
T_6	(Entire plot harvested as forage at 75 DAS	--	--	7742.00	7742.00
	SE $\pm$	296.64	226.64	2496.42	366.63
	CD at 5%	--	--	49.99	706.59

Note : Price for grain Rs 150 per quintal;
Price value for stover and forage Rs 18 per quintal

with returns of DHM-103 (Rs 66,285) and significantly superior to African tall (Rs 4,342). The per cent increase in monetary returns with Ganga-5 on grain yield over African tall was 53.15% and 5.82% over DHM-103 (Table 7a).

Monetary returns progressively increased with increase of plant density from S_1 (Rs 5077) to S_2 (Rs 5,816) and S_3 (Rs 6,385) and their differences were statistically significant. Such increase of monetary retruns of grain yield over normal population of (S_1) was Rs 738 (14.5%) with higher population of S_2 and Rs 1,307 (25.7%) with S_3.

Thinning treatments had not shown any significant effect on monetary returns due to grain yield as a result of negligible variation between treatments.

For a given maize variety, change in spacing from S_1 to S_3 (in increase of population) showed progressive increase in monetary returns. Such an increase in monetary returns was signficant with a change from S_1 to S_3 in case of Ganga-5, S_1 to S_2 in DHM 103 and similarly from S_1 to S_2 in African tall. The increases observed in other treatments were not significant.

The interaction effects of variety x thinnings; spacings x thinnings; varieties x spacings x thinning treatments were not found signficant in respect of monetary returns.

4.8.2 Monetary Returns On Stover Yield

The monetary retruns on stover yield were significantly influenced by varieties, plant densities, thinning treatments, interction effects of varieties x spacings; varieties x thinning treatments and population x thinning treatments (Table 7).

Maximum monetary returns were observed with African tall (Rs 2262) which were significantly superior to returns of Ganga-5 (Rs 1,313) and DHM-103 (Rs 1,244). The per cent reduction of monetary returns on stover yield over African tall was 41.99, 45.00 with ganga-5 and DHM-103, respectively.

There was a significant increase of monetary retruns on stover yield with increased plant densities from S_1 (Rs 1,347) to S_2 (Rs 1664) and S_3 (Rs 1,815). Such increase of returns on stover yield over S_1 was Rs 317 and Rs 468 with S_2 and S_3, respectively. The monetary returns of S_2 and S_3 were on par with each other.

Thinning treatments had no significant impact in respect of monetary retruns on stover yield of control plot. There was a significant increase of returns on stover yield with higher plant densities from S_1 to S_2 and S_3 with African tall compared to other varieties.

V_3S_3 (African tall x highest plant density) resulted in maximum monetary returns and which was significantly superior to the rest. The interaction effect of African tall x thinning treatments were significantly superior in respect of monetary returns on stover yield as compared with Ganga-5 x thinning treatments and DHM-103 x thinning treatments. V_3T_5 (African tall x thinning at 75 DAS) obtained maximum returns on stover yield (Rs 2,502) as compared to other interaction treatments whereas least value was observed in V_2T_2 (Rs 1,178).

Maximum return was observed with S_3T_5 (Rs 1,828) whereas least monetary returns were observed with S_1T_4 (Rs 1,208) and these two interactions differences were statistically not significant.

4.8.3 Monetary Returns On Forage Yield

African tall's monetary returns on forage yield (Rs 1746), were significantly higher than those DHM-103 (Rs 1,539) and Ganga-5 (Rs 1,527).

Monetary returns on forage yield progressively increased with increase of plant densities from S_1 (Rs 1,307) to S_2 (Rs 1,638) and S_3 (Rs 1,805). Such increase of returns on forage with change of population rate over S_1 was 19.56 per cent and 31.33 per cent with S_2 and S_3 respectively. Monetary returns obtained in S_3 due to forage were significantly superior to the rest of spacings of S_2 and S_1, inturn returns of S_2 were also significantly superior to S_1 (Table 7a).

There were significantly superior returns on forage from T_6 (entire plot harvested at 75 DAS considered as forage) i.e., Rs 7.742, compared to the rest. The returns were next best in T_5 (Rs 856) which were superior to T_4 (Rs 645), inturn T_4 superior to T_3 (Rs 249) and inturn T_3 superior to T_2. Lowest returns were obtained in T_1 where no thinning was practiced.

The forage yield obtained by thinning in African tall resulted in maximum monetary retruns due to forage which were significantly superior to the rest. The returns from forage with DHM-103 was second in order but was on par with returns of Ganga-5. Monetary returns gradually increased with change of population rate from S_1 to S_3 in all three varieties of maize studied. Such increase of remuneration on forage with higher population levels was more reflected in African tall as compared to Ganga-5 and DHM-103. Similarly in African tall, monetary returns were increased with increase of population from S_1 (Rs 1361 to S_2 (Rs 1,764) and S_3 (Rs 2,110). While DHM-103, there was a progressive increase of returns with plant densities from S_1 (Rs 1,384) to S_2 (Rs 1594) and S_3 (Rs 1,640). Similarly in Ganga-5 monetary returns on forage was high with higher population levels of S_3

(1663), S_2 (Rs 1,555) as compared with S_1 (Rs 1,361). V_1S_3 obtained maximum returns (Rs 2,111) whereas least monetary returns were from V_1S_1 (Rs 1,361) and V_2S_1 (Rs 1,384).

Plants thinned at 30 DAS (T_2), 45 DAS (T_3), 60 DAS (T_4) and 75 DAS (T_5) showed progressive increase of returns on forage when compared with T_6 (entire plot harvested as forage at 75 DAS) in all varieties of maize. Such increase of returns on forage was lowest in Ganga-5 and DHM-103 as compared to African tall. V_3T_5 resulted in maximum returns (Rs 8,595) whereas least value was with V_1T_2 (Rs 64).

The interaction effects of $V_3S_3T_6$ resulted in maximum returns on forage which were significantly higher than remaining interaction effects whereas least value was observed with $V_1S_1T_2$ and $V_1S_2T_2$ (Rs 4,482). The values of remaining interactions were in these extremes.

4.8.4 Gross Monetary Returns Due To Grain, Stover and Forage Yield (Combined)

The data pertaining to gross returns are presented in Table 7a, 7b Fig.8,9 and 10. The differences due to varieties, spacings (population levels), thinnings and their interactions were found to be statistically significant.

Growing of variety "Gange-5" resulted in maximum return of Rs 9,492 per hectare. This return was on par with the returns of DHM 103 (Rs 9,069) and was superior to African tall (Rs 8,350). Gross returns gradually increased with increase of plant population from S_1 (Rs 7,795) to S_2 (Rs 9,118) and S_3 (Rs 10,004). The per cent increase of returns over normal population (S_1) was 16.97 and 28.33 with higher populations of S_2 and S_3 respectively. Gross returns obtained in S_3 were highest which was significantly superior to the rest. The results of S_2 were second in order and were significantly superior to returns of S_1.

The thinnings did not result in any significant effect on monetary returns compared to "control". The returns of T_6 (entire harvest at 75 days) were higher and was at par with T_5 and T_4 returns and superior to T_1, T_2 and T_3.

Gross monetary returns gradually increased with increase of plant population from S_1 to S_2 and S_3 in all varieties of maize. Such increase of gross returns with plant population were more pronounced in African tall as compared to DHM-103 and Ganga-5. The Ganga-5 higher returns were obtained with increase in population from S_1 (Rs 8,658) to S_2 (Rs 9,597) and S_3 (Rs 10,222). In this variety, the per cent increase of returns over S_1 was 10.84 with S_2 and 18.06 with S_3. Similarly with

Table 7b Effect of varities x spacing (V x S); varieties x thinnings (V x T) interactions on gross monetary returns (Rs)

Treatments		V x S			V x T					
		S_1	S_2	S_3	T_1	T_2	T_3	T_4	T_5	T_6
	Varieties									
V_1	Ganga-5	8658	9597	10222	7898	7497	8394	8674	9199	7325
V_2	DHM-103	7911	9237	10059	7598	7411	7812	8157	8597	7308
V_3	Africantall	6813	8486	9750	7087	6907	6497	6915	7499	8595
	SE $\pm$			553						600
	CD at 5%			1273						1233

Note : Gross monetary returns = Cumulative returns of grain, stover and forage (Rs)

T1 Control No thinning
T2 Thinning at 30 DAS
T3 Thinning at 45 DAS
T4 Thinning at 60 DAS
T5 Thinning at 75 DAS
T6 Entire plot harvested as forage at 75 DAS

S1 60 x 25 cm (66,666 plants/ha)
S2 45 x 15 cm (1,48,148 plants/ha)
S3 30 x 15 cm (2,22,222 plants/ha)

DAS = Days after sowing

Fig. 8 Effect of varieties on gross monetary returns (Rs.)

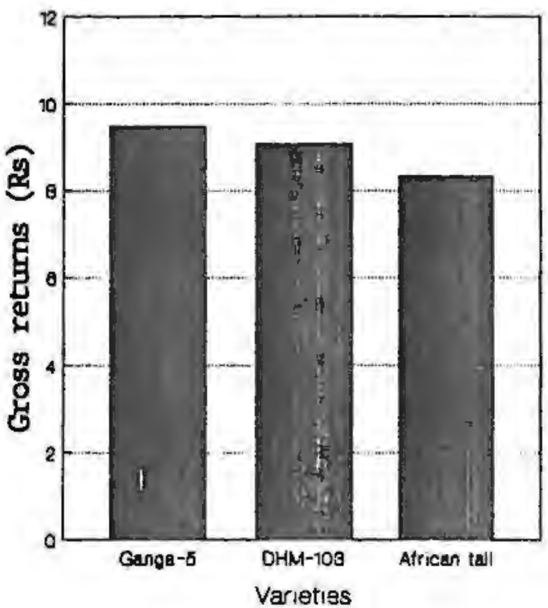


Fig. 9 Effect of spacings on gross monetary returns (Rs.)

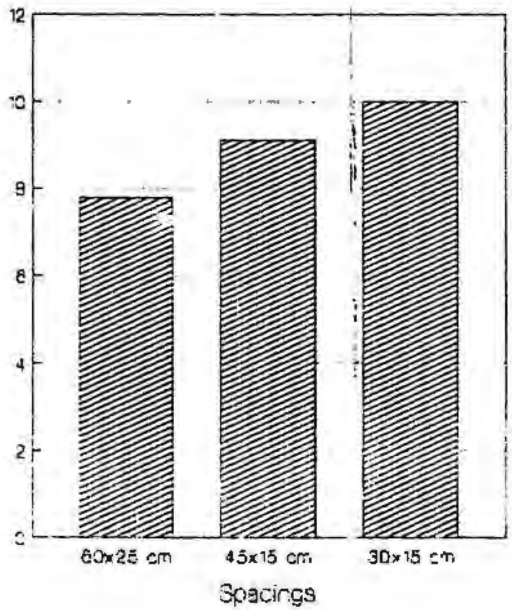
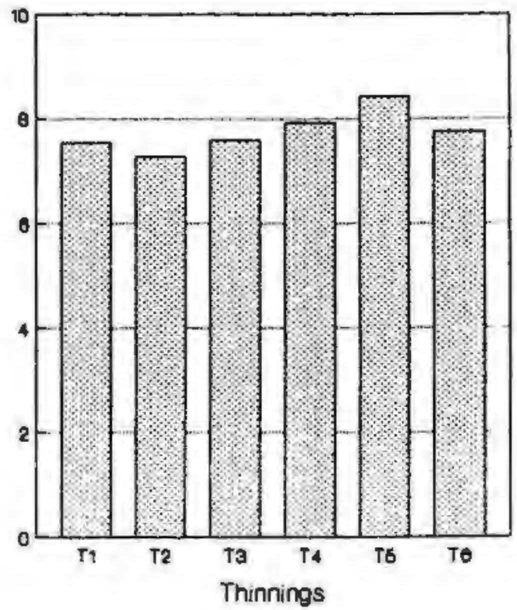


Fig. 10 Effect of thinning treatments on gross monetary returns (Rs.)



DHM-103 the monetary returns were higher with higher population levels i.e., S_3 (Rs 10,059) and S_2 (Rs 9,237) when compared with S_1 (Rs 7,911). The per cent increase of gross returns over S_1 was 16.76 with S_2 and and was 27.15 with S_3. In African tall, change of population rate from S_1 to S_2 and S_3 resulted in higher monetary returns from Rs 6,813, Rs 8,486 and Rs 9,750, respectively. The per cent increase of returns over S_1 was 24.55 and 43.10 with higher population of S_2 and S_3, respectively. Maximum return was observed with V_1S_3 (Rs 10,222) whereas least return was observed with V_3S_1 (Rs 6,813). The values of remaining interactions due to varieties and spacings were in between these two high values. Thus change in population rate from S_1 to S_2 and S_3 resulted in higher monetary returns especially in 'African tall' compared to DHM-103 and Ganga-5.

In general the differences due to varieties x thinnings were statistically significant. The thinnings have improved the returns to the maximum possible extent in Ganga-5 and were statistically on par to improvements made in DHM-103, which were inturn superior to 'African tall'. The increased returns with Ganga-5 (V_1T_5) were maximum and were on par with returns of control treatments of Ganga-5,DHM 103 but superior to control of 'African tall'. The total returns obtained by T_6 (total crop harvesting at 75 days) also showed good returns, which were also on par with the returns of 'control' but significantly lower than V_1T_5.

Change in population rate from S_1 (normal population level) to higher population level of S_2 and S_3 resulted in higher returns at all thinning treatments, but these differences were not statistically significant. However maximum return was observed with S_3T_5 (Rs 9,115) whereas least value was observed wtih S_1T_1 (Rs 6,272). The values of remaining interaction treatments were in between these two extreme values.

$V_1S_3T_5$ yielded the maximum return of Rs 9,694 per hectare, whereas the least amount was realised with $V_3S_1T_1$ (Rs 5,448). However, the differences betweem these interactions were not statistically significant.

DISCUSSION

CHAPTER V

DISCUSSION

5.1 PLANT STAND

Plant stand increased from 66,666 plants ha^{-1} (60 x 25 cm) to 1,48,148 plants per ha^{-1} (45 x 15 cm) and 2,22,222 plants per ha^{-1} (30 x 15 cm) at all stage of crop growth. Higher plant stand in closer spacing was mainly due to use of higher seed rate. During subsequent thinning operations at 15 days interval starting from 30 DAS and continued upto 75 DAS lead to progressive decrease of plant population with advancement of crop growth. Wherever thinning opration (removal of alternate hills) resulted in reduction of plant density. Similar findings were made by Singh and Singh (1971), Hati and Panda (1970), Rathore *et al*., (1976), Raghotham Reddy (1984), Wang *et al*. (1987).

5.2 PLANT HEIGHT

A significant variation in respect of plant height between varieties were not observed at all stages of crop growth except at 75 DAS. At this stage, African tall recorded significantly higher plant height as compared to Ganga-5 and DHM-103. Thus the vertical growth rate of African tall (known as a tall growing variety) was very rapid than DHM-103 and Ganga-5 at 75 DAS and its growth steadily increased with age of the crop. Such steady growth was not observed in Ganga-5 and DHM 103. Similar observations were made by Hati and Panda (1970), Raghotham Reddy (1984), Wang et al. (1987).

The differences between plant population, thinning, interaction of varieties x spacings, varieties x thinnings, varieties x spacing x thinnings were not found significant in respect of plant height at all stages of crop growth. Similar observations with plant densities were made by Rathore et al., (1976), Taneja et al. (1984), Singh and Tajbaksh (1986) and with thinning treatments by Arnel et al.(1969) and Shafshak et al. (1984).

5.3 DRY MATTER

African tall produced more dry matter, over Ganga-5 and DHM-103. The rate of dry matter accumulation was high during 3rd and 4th month after sowing. African tall produced more dry weight as a result of more plant height and continuity of source activity or vegetative growth as evidenced by higher dry weight of vegetative parts.

Total dry matter (Plant basis) decreased gradually with increase in population density from 66,666 plants ha^{-1} to 1,48,148 plants ha^{-1} and 2,22,222 plants per ha^{-1} in all varieties of maize. Such reduction of dry weight was more pronounced in DHM-103 and Ganga-5 at all stages of crop growth. The reduction in dry weight of plant was directly proportional to higher population levels. Reduction in dry matter per plant under higher population level is due to biological pressure and heavy competition existing for light, nutrients, moisture and available environment resources. Similar results were reported by several researchers (Stivers et al. 1971; Pucaric and Gotlin 1973, Krishnamurthy et al. 1974a; Raghotham Reddy, 1984, Singh and Tajbakhsh 1986 and Wang et al., 1987).

The interaction of varieties and thinning treatments were found to be significant at 60 DAS to harvest. The interaction effects of African tall with thinning treatments were significantly superior to Ganga-5 x thinning treatments and DHM 103 x thinning treatments at all stages of crop growth. The dry matter production was reduced with thinning treatments from 60 DAS to 90 DAS and 120 DAS, whereas at the time of harvest, all thinning treatments except T_2 were on par with control in respect of dry matter production. In DHM-103, T_3 at 60 DAS; T_2, T_3, T_4, T_5 at 90 DAS recorded significantly lesser dry matter as compared with control while at harvest thinning treatments had no impact on dry matter production as comapred with control.

So far upto 1990, literature on interaction of spacings x thinning in respective of dry matter is not available.

5.4 DAYS FOR 50 PER CENT TASSELING AND SILKING

DHM-103 took lesser number of days in respect of silking as compared to Ganga-5 and African tall. Similarly Ganga-5 took lesser number of days to 50 per cent tasseling as compared to DHM-103 and African tall. The differences in days to 50 per cent flowering and 50 per cent tasseling signifciantly varied due to varietal characters.

Sharma and Gupta (1968) stated that days to silking were significantly less in Ganga safed hybrid Makka-2 (58.7) and Ganga hybrid Makka (57.1) compared to Ganga hybrid Makka 101 (60.85) and Rudrupur local (60.45).

5.5 YIELD COMPONENTS

The cob weight, number of grains per cob were high with Ganga-5 and were significantly superior to those of DHM-103 and African tall. The superiority of Ganga-5 to DHM-103 and African tall might be due to effective translocation and distribution of drymatter towards reproductive parts (cob and grain).

The variation in grain number and cob weight due to dry matter partitioning through genotypic potentiality was reported by several researchers (Singh 1967; Krishnamurthy et al., 1974a and Raghotham Reddy, 1984).

Change in population rate from normal population (S_1) to higher population levels of 1,48,148 plants ha^{-1} (S_2) and 2,22,222 plants ha^{-1} (S_3) resulted in decrease of cob weight, grain number and 100-seed weight. Similar results were reported by Singh (1967), Goydani and Singh (1968), Sharma and Gupta (1968), Krishnamurthy et al. (1974 a & b), Cloninger et al. (1975), Choudhary (1981) and Remison and Lucas (1982). Similarly Krishnamurthy et al. (1974 a & b) observed variation in several of the yield attributes due to increase in the population stands. Raising the level of population from 45,000 to 75,000 ha^{-1} reduced the number of grain rows cob^{-1}, grains row^{-1}; grains cob^{-1}; grain $yiled^{-1}$; shelling percentage and harvest index Krishnamurthy et al., (1974a) but the difference were not significant in another study Krishnamurthy et al., (1974b).

Thousand grain weight also significantly differed from 237.3 to 205.3 g between the populations of 50,000 to 1,00,000 ha^{-1} as reported by Goydani and Singh (1968). Such significant reduction in 1000-grain weight with increase in plant population was reported by

Cloninger *et al.* (1975). Shukla *et al.* (78) observed significant decrease in number of grains cob^{-1} from 552 to 424 and 1,000 grains weight with increase in population density to 70,000 ha^{-1} than compared to 50,000 ha^{-1}.

Cob weight of NCA maize cultivar registered significantly lower value of 103 g at popualtion level of 92,600 ha^{-1} with the corresponding value with 37,000 ha^{-1} was 169 g (Choudhary, 1981).

Thinning treatments had no impact on cob wegiht grain number and 100-seed weight.

In African tall, thinning at 75 DAS (T_5) resulted in more cob weigh (168 g) as comapred to control (152 g), thinning treatments of T_2 (150 g), T_3 (158 g) and T_4 (154 g). Whereas in DHM-103, there was a significant reduction of cob weight with thinning treatments of T_2 (160 g), T_3 (168 g), T_4 (165 g) and T_5 (161 g), when compared to control (177g). So far upto 1990, literature on varieties x thinning treatments pertaining to cob weight and grain number is not available.

5.6 YIELD

5.6.1 Grain Yield

Maximum grain yield of 44.35 q ha^{-1} was produced with Ganga-5, which was significantly superior to that of DHM-103 (41.90 q ha^{-1}) and African tall (28.94 q ha^{-1}). Similar trend was also observed in per plant yield.

Highest yield of this genotype was mainly due to its genetic potentiality to utilize the natural resources in an efficeint way from the initial stages of the crop growth and its adaptability to agro-climatic conditions. African tall and DHM-103 recorded lesser yield, due to lower vlaues of yield components of (cob weight, number of cobs per plant, 1000-seed weight) and dominance of vegetative growth as evidenced by dry weight of vegetative parts. Reddy (1966), Singh (1967), Sharma and Gupta (1968), Giesbrecht (1969), Singh and Leng (1970), Verma and Singh (1970), Hati and Panda (1970), Patil et al., (1971) Bapna and Trivedi (1971), Pathak et al. (1971), Srivastava and Mahmood (1971), Singh and Singh (1971), Mandloi et al.(1972), Panda et al. (1974), Krishnamurthy et al. (1974), Mock and Heghin (1976), Bhag Singh (1976), Rathi and Ali (1972), Sharma (1978), Nayak et al. (1981) and Jain et al. (1982) also observed differences in yield between hybrids composites, improved and local varieties.

Closer spacing (higher population levels) also resulted in decreased yields per plant mediated by the reduction number of grains per cob, cob wegiht, 100-seed weight, number of cobs per plants and inadequate production of vegetative parts. Grain yield per hectare was increased with increase of population levels from 66,666 plants to 2,22,222 plants ha^{-1}. The results show that increasing the population levels per unit area would sharply affect the per plant performance (ancillary characters of yield). Better growth of individual plant in low plant density and resultant utilization of accumulated photosynthates influenced the growth and development of cobs, grain number and better filling. Similar results were reported by Singh (1967), Goydani and Singh (1968), Krishnamurthy et al.(1974a) Choudhary (1981), Remison and Lucas (1982), Navarro et al. (1985), Bakelana et al. (1986), Singh and Tajbhakhsh (1986), Gentinetta et al. (1987), Reddy et al.(1987), Dwivedi and Tripathi (1988) and West et al. (1989).

The grain yield per hactre was maximum (42.57 q ha^{-1}) with population density of 2,22,222 plants (S_3) which was significantly superior to 1,48,148 plants ha^{-1} (38.77 q ha^{-1}) and 66,666 plants ha^{-1} (33.85 q ha^{-1}). Plants suffered individually in respect of growth, and per plant yield. However, such loss in the yields was more than compensated due to higher number of plants per unit area under higher population levels. Results are suggestive that higher yields can be obtained by increasing population levels and sacrifying the individual plant performance. The disadvantage with higher population levels is utilization of environmental resources like light, water and nutrients more intensively but with lesser efficiency by the plants. If the plant performance is increased, it leads to low utilization efficiency of available resources for realising higher yield. Therefore a balance must be struck between, plants per unit area vs per plant performance.

The internal competition within the individual plant between vegetative and reproductive plants become most severe as competition between plants increases with higher population densities. As plant density increases, changes may occur in the allocation of assimilates to different plant parts as a result of which a greater proportion of plants may become barren and also there may be a critical period for light in relation to grain formation at higher population levels. Similar increase in grain yields were reported by Sharma and Gupta (1968) upto 60,000 palnts ha^{-1}; Verma and Singh (1970) upto 90,000, plants ha^{-1}; Kaushak and Gupta (1970) upto 43,000 [illegible] ha^{-1} Bapna and Trivedi (1971) upto 41,650 ha^{-1}. Agrawal *et al.* (1974) upto 55,555 ha^{-1}, Jain *et al.* (1975) upto 56,000 ha^{-1}, Shukla *et al.*, (1978) upto 50,000 ha^{-1} and Choudhary (1981) upto 61,700 plants ha^{-1}. As reported the grain yield plant^{-1} between 66.6 (P_2) and 76.1 (P_3) thousands ha^{-1} populations was not significant, but grain yield ha^{-1} was significantly lower in 66.6 thousand ha^{-1} indicating that the population level per unit area in P_2 was inadequate for utilizing the natural and applied resources fully.

For a given variety change in population rate from S_1 to S_3 showed progressive increase in grain yield. Such increase in grain yield with enhanced plant population was more pronounced in Ganga-5 as compared to DHM-103 and African tall indicating a necessity for further detailed investigation.

The grain yield of Ganga safed-2 maize was maximum under 60,000 plants per ha^{-1} which was higher by 11.65 and 22.83 per cent more than the yield obtained from 40,000 plants per ha^{-1} in two years (Sharma and Gupta, 1968). Increase in population produced a substantial increase in grain yield with hybrids from 30,000 to 75,000 plants per hectare. Similalry Verma and Singh (1970) observed that grain yield with 90,000 plants per ha^{-1} was significantly higher by 11.55 and 35.84 per cent than60,000 and 40,000 plants per ha^{-1} respectively. Signifciant difference in grain yield as influenced by population were also reported by Agrawal et al. (1974) from Kanpur in kharif season on Ganga-5 maize hybrid upto a population of 55,556 per ha^{-1}. Jain et al. (1975) upto 60,000 plants per hectare, Barthakur et al. (1975) on Ganga-101 Maize cultivar upto 56,000 plants per hectare, Verma and Singh (1970) on Ganga-safed-2, maize upto 61,700 plants per hectare. However significant decrease in grain yield beyond 50,000 plants per hectare either at 60 or 70,000 plants per hectare was reported by Shukla et al.(1978). Decline in yield at a population density of 90,000 per hectare was also observed by Jain et al. (1975) and Choudhary (1981).

Navarro et al. (1985) recorded that grain yield was increased with increase of plant population from 55,000 to 1,00,000 plants ha^{-1} in CVP-3311 at Cardoba. Reddy et al.(1987) observed that grain yield was increased with increase of population from 59,200 to 88,800 plant ha^{-1}. Highest grain yield of 4.6 t/ha in 1983 and 5.13 in 1984 were observed with 76,000 plants/ha in maize CV x 440.

Boyan (1986) recorded that grain yield per hectare was lowest in maize hybrids at lowest plant density, while grain yield increased with increased population to various degrees. Optimum yield was obtained at 70,000 plants per hectare.

5.6.2 Stover Yield

Stover yield was signifciantly high in African tall (125.68 q ha^{-1}) as compared to Ganga-5 (72.99 q ha^{-1}) and DHM-103 with (69.13 q ha^{-1}). Highest yield of this genotype was mainly due to its genetic potentiality to utilize available natural resources in efficient way from the initial stages of the crop grwoth and adaptability to agro-climatic conditons. In present investigation African tall recorded more vegetative growth in terms of plant height, dry weight of vegetative parts. Similar findings were made by several researchers (Singh and Bose, 1965; Reddy 966; Singh 1967; Singh and Leng 1970;

Saxena *et al.*, 1971, Mandloi *et al.*, 1972; Panda *et al.*, 1974; Krishnamurthy *et al.*, 1974; Jain *et al.*, 1975; Singh *et al.*, 1980; Nayak *et al.*, 1981; Jain *et al.*, 1982; Raghotham Reddy, 1984). Panda *et al.* (1974) observed that Ganga-2 (7,780 kg) and Kisan (7,690 kg) gave significantly lowest stover yield when compared with Ganga-2 (7,780 kg) and Ganga-5 (8,960 kg). Molan (7,940 kg ha^{-1}) produced significantly higher stover yield than Ganga-5 (5,470 kg) and Bassi (3,320 kg) (Jain *et al.*, 1982).

High plant density of 222 thousands plants ha^{-1} gave highest yield (100.85 q ha^{-1}) which was significantly superior to 148 thousand plants ha^{-1} (92.48 q ha^{-1}) and 66.6 thousand plants ha^{-1} (74.82 q ha^{-1}). The plants suffered individually with high plant density in dry matter production, cob weight, grain number, 1000-seed weight and stover yield. However, such reduction in stover yield was more than compensated due to more number of plants per unit area under higher population level. The results revealed that stover yield gradually increased with increase of plant density. Similar results were obtained by Kaushak and Gupta (1970); Bapna and Trivedi (1971); Krishnamurthy *et al.* (1974a); Raghotham Reddy (1984) and Amoruwa *et al.* (1987).

Maximum stover yield was obtained by control treatment i.e., T_1 (90.01 q ha^{-1}) and was significantly superior to early thinning at 30 DAS: T_2 (86.18 q ha^{-1}). Whereas remaining thinning treatments of T_3, T_4 and T_5

were on par with control.Stover yield was increased with increase of plant population S_1 to S_3 in all treatments.

5.6.3 Forage Yield

For a given variety of maize, change in popual-tion rate from S_1 to S_2 and S_3 showed a progressive increase in forage yield. Such increase in forage yield was maximum in African tall followed by DHM-103 and Ganga-5. This was mainly due to harvest or thinning of more number of plants in closer spacing. Thus contribution of more plants has enhanced the contribution or availability of forage.

Holliday (1960) reported that in forage crops, which mainly constituted the vegetative part, asymetric relationship existed between seed rate and yield. Therefore, use of increased seed rate is an insurance to get higher plant density without reduction in yield and without deteriorating quality of forage. These increases may be due to taller plants and higher fodder yield per meter row length. Soelaeman et al. (1987) reported that grain yield and forage decreased with time of thinning, while fresh forage increased. Wang et al. (1987) studied maize hybrid Tainung-351 which was grown at spacings of 80 x 10; 80 x 20; 80 x 40 cm giving 1,25,000; 62,500 or 31,250 plants ha^{-1} and the higher densities were thinned to the lower densities at silking or 2 weeks later. Thinning treatments, gave higher yields than control (without thinning at all plant population levels) at same final plant density.

5.7 GROSS MONETARY RETURNS

Gross monetary returns were significantly high in Ganga-5 (Rs.9,492) and were on par with DHM-103 (Rs.9,069) and both were significantly superior to African tall (Rs.8,350). Gross monetary returns were maximum in Ganga-5 because of higher returns on seed yield and moderate on stover and forage. Whereas in DHM-103, retruns on grain, stover and forage were moderate. In case of African tall, which recorded lowest gross monetary returns because of reduced grain yield, though stover and forage yields were high which could not compensate the reduction due to grain yield. Thus Ganga-5 and DHM-103 are suitable for seed purpose i.e., for grain yield and stover while African tall is suitable for forage purpose only. This emphasis, the need for selection of suitable genotype for attaining higher net returns at a given level of input resource and management practices. The variation in net returns with genotypes was reported by Reddy (1966), Krishnamurthy and Martin (1972) and Tewari and Awasthi (1975), Raghotham Reddy (1984).

Gross returns gradually increased with increase of plant population from S_1 (Rs.7,795) to S_2 (Rs.9,118) and S_3 (Rs. 10,004). Gross monetary returns gradually increased with increase of plant popualtion from S_1 to S_2 and S_3 in all varieteis of maize. Such increase of gross returns with plant population was more pronounced in African tall as compared to DHM-103 and Ganga-5.

The thinnings did not result in any significant effects on returns compared to control. The returns of T_6 (entire harvest at 75 days) resulted in higher returns which were on par with T_5 and T_4 returns and superior to T_1, T_2 and T_3. Thinnings improved the returns to the maximum possible extent in Ganga-5 and were statistically on par to improvements made in DHM-103 which in turn were superior to that in Afircan tall.

The total returns obtained by T_6 (total crop harvesting at 75 days) also showed good returns which were also on par with returns of control but significantly lower than V_1T_5.

Change in population rate from S_1 (normal population level) to higher population levels of S_2 and S_3 resulted in higher returns at all thinning treatments. This shows the possibility of raising population by closer spacing which could be thinned out at various times for forage, without any deterimental effect on grain yield as well as monetary returns.

SUMMARY

CHAPTER VI

SUMMARY

Present investigation was carried out at College Farm, Rajendranagar, Hyderabad-500 030 during *rabi*, 1989-90 season with 3 varieties (Ganga-5, DHM-103 and African tall) at 3 spacing level (60 x 25 cm, 45 x 15 cm and 30 x 15 cm) as main treatments and 5 thinning treatments i.e., thinning at 30 days, 45 days, 60 days, 75 days and without thinning as control plot as sub-treatments in a split plot design with two replications.

Vertical growth of African tall was very rapid compared to Ganga-5 and DHM-103 with age of the crop and significantly differed with each other at 75 DAS and at harvest. African tall recorded higher drymatter production over DHM-103 and Ganga-5, was 18 and 44 g at 90 DAS, 120 DAS and at harvest. African tall took more number of days for 50 per cent silking and tasseling than Ganga-5 and DHM-103. While Ganga-5 found superior in number of cobs per plant, cob weight, grain yield, number of grains per cob and grain yield when compared to African tall and DHM-103. Grain yield and its monetary returns were maximum with Ganga-5 and were on par with DHM-103 and both of them were significantly superior to African tall. Whereas the stover and forage yields and their monetary returns were more with African tall

than Ganga-5 and DHM-103. Gross returns due to cumulative value of grain, stover and forage was maximum in Ganga-5 (Rs 9,492) which was Rs 1,142 and 423 higher than that from African tall and DHM-103, respectively.

Drymatter production per plant decreased with closer spacings of 45 x 15 cm and 30 x 15 cm when compared with wider spacing of 60 x 25 cm (normal spacing) at all stages of crop growth except at 30 and 60 DAS. Ganga-5 and African tall grown under normal spacing of 60 x 25 cm produced maximum dry weight at 90, 120 DAS and harvest. While in DHM-103, spacing of 45 x 15 cm recorded higher drymatter over wider spacing of 60 x 25 cm as well as closer spacing of 30 x 15 cm at 90 and 120 DAS. However, this trend was altered at harvest. During this stage, plants of DHM-103 grown under wider spacings of 60 x 25 cm recorded maximum dry weight (372 g) which was significantly superior to 45 x 15 cm (345 g), and 30 x 15 cm (321 g). Number of cobs per plant, cob weight, number of grains per cob, and per plant yield gradually decreased with decrease in spacing from 60 x 25 cm to 45 x 15 cm and 30 x 15 cm in all cultivars studied. Thus highest population and narrow spacing affected the plant performance leading to reduction in yield per plant through yield attributes in all the cultivars studies. But, the overall yield was improved in closer spacings due to higher population, contributing for it than normal spacing (60 x 25 cm).

Higher monetary returns were realised over normal population level (66,666 plants per hectare) was Rs 1323 and Rs 2209 with higher population levels of 1,48,148 and 2,22,222 plants ha^{-1}. Gross monetary return per hectare increased in a llinear fashion with increase in plant population from 66,666 plants ha^{-1} to 1,148,148 and 2,22,222 plants ha^{-1} (which were reduced to half by removing alternate plants at scheduled stage) in all varieties of maize. The increase in population was either through reducing inter row spacing from 60 to 45 and 30 cm or intra row spacing from 25 to 15 cm. Such increase of gross monetary returns from normal to highest population level (2,22,222 plants ha^{-1}) was Rs 1564 in Ganga-5, 2148 in DHM-103 and Rs 2937 in African tall. An increase of gross monetary returns from normal to medium population of 1,48,148 plants ha^{-1} was Rs 939 in Ganga-5, Rs 1326 in DHM-103 and Rs 2937 in African tall. Ganga-5 grown under 30 x 15 cm spacing or highest population level (Studied) gave maximum returns of Rs 10,222. While African tall grown under normal spacing or population level (60 x 25 cm : 66,666 plants ha^{-1}) recorded least gross monetary returns of Rs 6813. The values in gross monetary returns due to other interaction effeccts of varieties x spacings were in between two extremes. Thus it clearly shown that change in population rate through spacing from 60 x 25 cm to 45 x 15 cm and 30 x 15 cm resulted higher monetary returns especially more in African tall as compared to DHM-103 and Ganga-5.

Thinning treatments i.e., T_2 to T_5 produced almost equal drymatter to the control (T_1) during 120 DAS and harvest and their differences failed to reach significance at 90, 120 DAS and at harvest. It is a matter of promise that by growing more plants initially and thinning them later had not affected the prospects of grain yield. In this process a good amount of green fodder supply could be achieved which hither to was not realised. The returns on forage of T_6 (entire plot harvested at 75 DAS) resulted in higher returns which was at par with T_5 and T_4 returns and was superior to T_1, T_2 and T_3. These thinnings have improved the total returns (due to grain, stover and forage) to a maximum possible extent in Ganga-5 which were statistically on par to improvements made in DHM-103, inturn both were superior to African tall. The inceased returns with Ganga-5 (V_1T_5) were maximum and were at par with returns of control treatments of Ganga-5 and DHM-103 but were superior to control of African tall. The total returns obtained by T_6 (total crop harvesting at 75 days) also showed good returns, which were also on par with returns of control but significantly lower than V_1T_5.

Thinning treatments increased dry weight per plant over control at 120 DAS and at harvest. Such increase of dry weight with thinning treatments over control was more pronounced under wider spacing 60 x 25 cm as compared to closer spacings of 45 x 15 cm and 30 x 15 cm. Irrespective of thinning treatments, plants grown under wider spacing of 60 x 25 cm recorded higher values in number of cobs per plant, cob weight, number of grains per cob and grain yield per plant when compared with 45 x 15 cm and 30 x 15 cm spacings. However, when hectare is considered, change in population rate due to spacings from 60 x 25 cm to 45 x 15 cm and 30 x 15 cm resulted in higher monetary returns on grain, stover and forage yield and their cumulative returns in all thinning treatments.

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APPENDICES

A P P E N D I X - A

Weekly mean meteorological data during crop growth period,

(from November 5th 1989 to 25th March 1990)

Standard week	Period	Temperature °C Maximum	Temperature °C Minimum	Relative humidity % 01714 hours	Relative humidity % 01414 hours	Bright sun shine hours/day	Total rainfall (mm)
45	5/11/89 to 11/11/89	29.70	14.50	74.00	35.00	8.10	1.80
46	12/11 - 18/11	29.00	11.40	77.00	39.00	6.40	--
47	19/11 - 25/11	30.10	11.90	69.00	34.00	10.40	--
48	26/11 - 2/12	29.70	10.80	78.00	33.00	10.50	--
49	3/12 - 9/12	28.90	11.40	73.00	29.00	10.50	
50	10/12 - 16/12	27.40	14.10	75.00	36.00	10.10	--
51	17/12 - 23/12	27.70	11.70	79.00	32.00	10.00	--
52	24/12 - 31/12	28.60	12.40	77.00	46.00	6.20	2.60
1	1/1/90 - 7/1/90	27.40	14.60	87.00	43.00	7.40	-
2	8/1 - 14/1	28.70	12.00	70.00	32.00	9.10	--
3	15/1 - 21/1	31.10	8.70	60.00	22.00	11.20	--
4	22/1 - 28/1	31.40	10.50	76.00	25.00	11.30	--
5	29/1 - 4/2	32.40	12.60	66.00	22.00	10.80	--
6	5/2 - 11/2	27.50	14.60	69.00	22.00	11.20	--
7	12/2 - 18/2	32.80	17.80	79.00	25.00	10.70	--
8	19/2 - 25/2	32.80	15.00	77.00	24.00	10.70	--
9	26/2 - 4/3	33.90	17.80	64.00	23.00	11.20	--
10	5/3 - 11/3	34.10	21.30	70.00	24.00	10.70	--
11	12/3 - 18/3	34.50	18.80	72.00	22.00	9.90	-
12	19/3 - 25/3	36.10	21.10	52.00	17.00	10.70	--

APPENDIX - 3

Plant stand at different stages of crop growth (- X 1000)

Varieties		Initial stage						30 Days						45 Days						60 Days						75 Days					
		T1	T2	T3	T4	T5	VxS Mean	T1	T2	T3	T4	T5	VxS Mean	T1	T2	T3	T4	T5	VxS Mean	T1	T2	T3	T4	T5	VxS Mean	T1	T2	T3	T4	T5	VxS Mean
V_1	S_1	66	63	64	64	65	64	66	33	64	64	65	58	66	33	33	64	65	52	66	33	33	33	65	46	66	33	33	33	33	40
	S_2	128	121	125	127	123	125	128	74	125	127	123	115	128	74	73	127	123	105	128	74	73	74	123	94	128	74	73	74	74	84
	S_3	198	192	193	192	193	194	198	113	193	192	193	157	198	113	113	192	193	143	198	113	113	117	193	128	198	113	113	112	113	84
Mean		131	125	127	128	127	128	131	73	127	128	127	110	131	73	73	128	127	100	131	73	73	73	127	89	131	734	73	73	73	70
V_2	S_1	66	64	63	64	63	64	66	33	63	64	63	58	66	33	33	64	63	52	66	33	33	33	63	46	66	33	33	33	33	40
	S_2	129	126	127	122	126	126	129	74	127	122	126	115	129	74	74	122	126	105	129	74	74	74	126	95	129	74	74	74	73	84
	S_3	200	190	192	195	190	193	200	113	192	195	190	178	200	113	117	195	190	162	200	113	112	113	190	146	200	113	112	113	112	34
Mean		132	127	127	127	126	128	132	73	127	127	126	117	132	73	73	127	126	106	132	294	73	73	126	96	132	73	73	73	73	70
V_3	S_1	66	64	63	64	64	64	66	33	63	64	64	58	66	33	33	64	64	52	66	33	33	33	64	46	66	33	33	33	33	40
	S_2	127	121	122	126	125	124	127	74	122	126	125	115	127	74	70	126	125	104	127	74	70	73	125	94	127	74	70	73	74	83
	S_3	195	195	188	192	195	193	195	113	188	192	195	177	195	113	113	192	195	162	195	113	113	112	195	146	195	113	113	112	112	129
Mean		129	127	125	127	128	127	129	73	125	127	128	116	129	73	72	127	128	106	129	73	72	73	128	95	129	73	72	73	73	84
S x T																															
S_1		66	64	64	64	64	64	66	33	64	64	64	58	66	33	33	64	64	52	66	33	33	33	64	46	66	33	33	33	33	40
S_2		128	123	125	125	125	125	128	74	125	125	125	115	128	74	72	125	125	105	128	74	72	73	125	94	128	74	72	73	73	84
S_3		198	192	191	193	193	193	198	113	191	193	193	178	198	113	113	193	193	162	198	113	113	112	193	146	198	113	113	112	112	130
Mean		130	126	126	127	127	128	130	73	126	127	127	117	130	72	73	127	127	106	130	73	73	73	127	95	130	73	73	73	73	85

Note : The reduction in population from initial stage to 75 DAS is due to thinning treatments

APPENDIX - C

Plant height (cm) at different stages of crop growth

Varieties	30 Days T1	T2	T3	T4	T5	VxS Mean	45 Days T1	T2	T3	T4	T5	VxS Mean
V_1 S_1	38	39	40	36	39	38	117	109	123	108	117	115
S_2	37	44	37	41	39	40	121	117	118	121	123	120
S_3	39	46	44	43	40	42	112	114	121	112	113	114
Mean	38	43	40	40	39	40	117	113	120	114	118	116
V_2 S_1	41	43	40	41	41	41	123	130	121	122	112	122
S_2	48	42	41	40	44	43	120	121	121	128	120	122
S_3	47	39	43	42	38	42	115	104	110	109	109	109
Mean	46	41	41	41	41	42	119	118	118	120	114	118
V_3 S_1	41	38	43	41	42	41	113	123	110	121	119	117
S_2	45	38	41	40	41	41	126	108	130	122	119	121
S_3	40	41	43	49	41	43	125	124	130	120	123	124
Mean	42	39	43	44	41	42	121	118	123	121	120	121
S x T												
S_1	40	40	41	40	41	40	117	121	118	117	116	118
S_2	43	41	40	40	41	41	122	115	123	124	121	121
S_3	42	42	43	45	40	42	117	114	120	114	115	116
Mean	42	41	41	42	41	41	119	117	121	118	117	118

Varieties	60 Days T1	T2	T3	T4	T5	VxS Mean	75 Days T1	T2	T3	T4	T5	VxS Mean
V_1 S_1	190	195	192	199	183	191	223	236	233	241	218	230
S_2	185	182	185	187	184	185	243	207	205	226	239	22[illegible]
S_3	178	194	188	181	191	186	203	236	217	200	211	213
Mean	184	190	188	189	186	187	223	227	218	222	222	223
V_2 S_1	204	199	192	184	186	192	239	218	228	226	209	224
S_2	192	199	201	203	195	198	217	236	224	232	229	227
S_3	189	179	181	173	186	182	217	209	222	212	241	220
Mean	195	192	191	187	189	191	224	221	225	223	226	224
V_3 S_1	187	201	200	194	197	196	250	284	295	290	274	279
S_2	191	186	179	194	196	189	264	263	287	283	287	277
S_3	196	206	185	210	188	197	263	255	234	287	246	257
Mean	191	197	188	199	194	194	259	267	272	287	269	271
S x T												
S_1	193	198	194	192	188	193	237	246	252	252	234	244
S_2	189	189	188	195	192	191	241	235	239	247	252	243
S_3	187	193	184	188	188	183	228	233	224	233	232	230
Mean	190	193	189	192	189	191	235	238	238	244	239	239

Dry matter production per plant (g) at different stages of crop growth

Varieties	30 Days T1	T2	T3	T4	T5	VxS Mean	60 Days T1	T2	T3	T4	T5	VxS Mean
V_1 S_1	13	14	13	12	11	12	92	73	75	78	81	80
S_2	10	13	12	13	11	12	130	120	110	131	115	121
S_3	12	12	12	13	11	12	78	101	78	88	101	89
Mean	11	13	12	13	11	12	100	98	88	99	99	97
V_2 S_1	13	13	13	13	12	13	94	95	78	101	69	88
S_2	11	13	13	12	11	12	87	114	80	92	96	94
S_3	15	13	12	12	12	13	98	73	74	100	98	88
Mean	13	13	12	12	11	12	93	94	77	98	88	90
V_3 S_1	12	10	15	13	9	12	136	109	98	107	130	116
S_2	11	13	12	11	13	12	114	84	94	114	104	102
S_3	16	13	12	13	13	13	122	100	104	103	108	107
Mean	13	12	13	12	11	12	124	98	99	108	114	108
S x T S_1	12	12	14	12	11	12	108	92	84	95	93	95
S_2	11	13	12	12	11	12	110	106	88	112	105	104
S_3	14	13	12	13	12	13	99	91	85	97	102	95
Mean	12	13	12	12	11	12	106	97	86	102	100	98

Varieties	90 Days T1	T2	T3	T4	T5	VxS Mean	120 Days T1	T2	T3	T4	T5	VxS Mean	At harvest T1	T2	T3	T4	T5	VxS Mean
V_1 S_1	246	215	313	201	[illegible]	238	327	334	396	[illegible]	[illegible]	334	352	382	407	388	339	[illegible]
S_2	229	172	194	177	[illegible]	189	288	260	286	[illegible]	292	276	348	344	333	334	387	[illegible]
S_3	142	208	137	173	[illegible]	161	254	288	240	253	262	259	326	365	321	320	322	[illegible]
Mean	206	198	214	184	[illegible]	196	289	294	307	276	[illegible]	290	342	364	354	347	349	[illegible]
V_2 S_1	209	138	133	153	154	157	285	277	306	[illegible]	279	288	357	365	390	380	373	[illegible]
S_2	163	176	182	195	193	183	291	282	284	318	[illegible]	294	337	355	359	348	327	[illegible]
S_3	177	163	150	183	[illegible]	169	169	226	263	[illegible]	[illegible]	[illegible]	319	311	308	321	347	[illegible]
Mean	183	159	155	177	[illegible]	170	248	262	284	[illegible]	280	274	338	344	352	349	349	[illegible]
V_3 S_1	208	215	274	215	[illegible]	225	307	330	340	399	339	343	407	374	406	416	402	[illegible]
S_2	191	193	199	260	[illegible]	210	291	316	290	306	300	300	385	371	367	369	381	[illegible]
S_3	195	204	206	229	[illegible]	208	294	304	281	292	305	295	340	369	336	352	371	[illegible]
Mean	198	204	226	235	[illegible]	214	297	317	304	332	315	313	377	371	370	379	385	[illegible]
S x T S_1	221	189	240	189	194	207	306	314	347	338	303	322	372	374	401	395	371	[illegible]
S_2	194	180	192	211	193	193	290	286	286	293	296	290	356	357	353	350	365	[illegible]
S_3	171	192	164	195	174	179	239	273	261	275	277	265	328	348	321	331	347	[illegible]
Mean	196	187	199	198	187	193	278	291	298	302	292	292	352	360	358	358	361	[illegible]

Days to 50 percent tasseling and silking

Varieties	Days for 50% tasseling					V x S	Days for 50% silking					V x S
	T1	T2	T3	T4	T5	Mean	T1	T2	T3	T4	T5	Mean
V_1 S_1	68.50	68.50	68.50	68.50	68.00	68.40	72.00	71.50	72.00	71.50	71.00	71.60
S_2	68.50	68.50	69.00	69.00	68.00	68.60	71.00	71.50	72.00	71.50	71.00	71.40
S_3	69.50	69.00	68.50	68.50	68.50	68.80	72.50	72.00	72.00	71.50	71.00	71.80
Mean	68.83	68.67	68.66	68.67	68.17	68.60	71.83	71.67	72.00	71.50	71.00	71.60
V_2 S_1	67.00	67.50	67.50	66.50	68.00	67.30	70.00	70.50	70.50	69.50	71.00	70.30
S_2	67.00	67.50	67.00	67.50	67.50	67.30	69.50	70.50	70.50	70.50	70.50	70.20
S_3	67.50	68.50	67.50	67.50	67.50	67.70	70.50	71.50	70.50	70.50	70.50	70.70
Mean	67.17	67.83	67.33	67.17	67.67	67.43	70.00	70.83	70.33	70.17	70.67	70.40
V_3 S_1	77.50	79.00	77.50	78.50	77.50	78.00	80.50	82.00	81.00	80.50	80.50	80.90
S_2	77.00	78.50	77.50	77.50	78.50	77.80	80.00	81.50	80.50	80.50	81.00	80.70
S_3	78.50	77.50	77.50	79.00	78.50	78.20	81.50	81.00	80.50	81.50	80.50	81.00
Mean	77.67	78.33	77.50	78.33	78.17	78.00	80.67	81.50	80.67	80.83	80.67	80.87
S x T												
S_1	71.00	71.67	71.17	71.17	71.17	71.24	74.17	74.67	74.50	73.83	74.17	74.27
S_2	70.83	71.51	71.17	71.33	71.33	71.23	73.50	74.50	74.17	74.17	74.17	74.10
S_3	71.83	71.67	71.17	71.67	71.50	71.57	74.83	74.83	74.33	74.50	74.00	74.50
Mean	71.22	71.61	71.17	71.39	71.33	71.34	74.17	74.67	74.33	74.17	74.11	74.29

APPENDIX - F

Yield components (No of cobs per plant, Cob weight, no. of grains per cob and 100-seed weight)

Varieties	Cob weight (g)						No.of Grains per Cob						100-seed weight (g)						No. of cobs per plant					
	T1	T2	T3	T4	T5	VxS Mean	T1	T2	T3	T4	T5	VxS Mean	T1	T2	T3	T4	T5	VxS Mean	T1	T2	T3	T4	T5	VxS Mean
V_1 S_1	174.7	171.0	190.8	190.8	176.3	180.7	514	519	531	525	509	519	27.1	26.1	29.1	27.5	27.2	27.4	0.8	1.7	1.2	1.6	1.5	1.4
S_2	160.2	171.7	162.2	152.3	172.5	163.8	517	525	513	506	518	516	24.6	26.2	25.0	23.4	26.6	25.2	0.6	0.9	1.1	1.0	1.2	1.0
S_3	163.2	161.7	153.8	162.3	158.8	159.9	514	523	518	516	523	518	25.4	24.5	23.6	24.9	24.8	24.6	0.6	0.9	0.9	1.0	0.9	0.9
Mean	166.0	168.1	168.9	168.4	169.2	168.1	515	522	521	516	516	518	25.7	25.6	25.9	25.3	26.2	25.7	0.7	1.2	1.1	1.2	1.2	1.1
V_2 S_1	183.0	161.0	181.5	163.0	176.5	173.0	512	509	514	513	511	511	28.9	25.6	28.7	25.6	26.8	27.1	0.9	1.6	1.8	1.5	1.5	1.4
S_2	184.0	174.5	181.5	180.5	152.0	174.5	509	514	513	514	506	511	30.8	27.6	27.8	28.5	23.7	27.7	0.7	1.1	1.0	1.1	1.1	1.0
S_3	165.0	145.5	142.0	152.0	155.5	152.0	518	510	512	507	521	513	25.8	22.8	22.5	23.8	23.7	23.7	0.6	0.8	1.0	1.1	1.0	0.9
Mean	177.3	160.3	168.3	165.2	161.3	166.5	513	511	513	511	513	512	28.5	25.3	26.3	25.9	24.7	26.2	0.7	1.1	1.3	1.2	1.2	1.1
V_3 S_1	187.0	158.5	166.5	140.5	184.5	167.4	514	52	511	514	511	514	28.8	24.8	26.0	22.5	28.9	26.2	0.4	0.8	0.8	0.8	0.7	0.7
S_2	134.5	140.0	145.7	162.5	166.5	149.8	497	513	509	512	503	507	22.3	23.8	22.6	25.4	26.3	24.1	0.6	0.9	0.9	1.0	1.0	0.9
S_3	133.0	150.5	162.3	159.0	155.0	152.0	516	506	510	512	501	509	21.8	23.7	25.7	25.5	22.8	23.9	0.5	0.9	1.0	1.0	0.9	0.9
Mean	151.5	149.7	158.2	154.0	168.7	156.4	509	513	510	513	505	510	24.3	24.1	24.8	24.5	26.0	24.7	0.5	0.9	0.9	0.9	0.9	0.8
S x T																								
S_1	181.6	163.5	179.6	164.8	179.1	173.7	513	516	518	517	510	515	28.3	25.5	27.9	25.2	27.6	26.9	0.7	1.4	1.3	1.3	1.2	1.2
S_2	159.6	162.1	163.1	165.1	163.7	162.7	508	517	512	511	509	511	25.9	25.9	25.1	25.8	25.5	25.6	0.6	1.0	1.0	1.0	1.1	0.9
S_3	153.7	152.6	152.7	157.8	156.4	154.6	516	513	513	511	515	514	24.3	23.7	23.9	24.7	23.7	24.1	0.6	0.9	1.0	1.0	0.9	0.9
Mean	164.9	159.4	165.1	162.5	166.4	163.7	512	515	514	513	511	513	26.2	25.0	25.7	25.2	25.6	25.5	0.6	1.1	1.1	1.1	1.1	1.0

APPENDIX - G

l [(grain; stover and forage (q/ha)]

Grain yield per hectare (q)					V x S	Stover yield per hectare (q)					V x S	Forage yield per hectare (q)						V x S
T1	T2	T3	T4	T5	Mean	T1	T2	T3	T4	T5	Mean	T1	T2	T3	T4	T5	T6	Mean
40.79	36.63	40.79	40.79	45.78	40.96	61.4	61.4	70.4	65.4	61.4	64.0	2.16	2.49	8.66	25.64	44.45	370.46	75.64
44.12	42.45	43.29	45.78	47.45	44.62	76.9	75.4	79.4	75.9	66.9	74.9	2.16	2.49	15.82	36.29	44.95	416.58	86.38
45.78	114.12	49.95	48.28	49.18	44.46	82.4	75.4	90.9	77.4	73.9	80.0	2.16	5.70	16.82	41.12	54.78	433.73	92.29
43.56	41.07	44.68	44.95	47.47	44.35	73.6	70.8	80.3	72.9	67.4	73.0	2.16	3.56	13.77	34.35	48.06	406.92	84.80
32.46	37.46	32.46	37.46	40.79	36.13	66.4	62.4	64.9	58.9	54.9	61.5	2.16	3.06	11.99	34.96	42.96	366.30	76.91
45.78	38.29	46.62	39.13	44.12	42.79	70.4	63.9	66.4	68.4	70.9	68.7	2.15	4.49	13.99	40.29	49.12	421.24	88.55
46.62	47.45	47.45	47.45	44.95	46.79	82.4	69.9	74.4	82.4	79.9	77.8	2.16	4.66	15.82	40.79	52.78	430.40	91.10
41.62	41.07	42.18	41.35	43.29	41.90	73.1	65.4	68.6	69.9	68.6	69.1	2.15	4.07	13.93	38.68	48.29	405.98	85.52
24.97	27.47	23.31	23.31	23.31	24.47	92.4	113.9	94.9	76.9	116.4	98.9	2.16	3.16	8.82	34.29	41.12	365.47	75.84
32.46	30.90	28.80	24.97	27.47	28.90	129.4	116.9	127.4	139.4	149.9	132.6	2.15	4.66	14.98	36.79	45.95	483.68	98.04
39.12	34.13	30.80	30.80	32.46	33.46	148.4	136.4	128.4	163.8	150.9	145.6	2.16	6.26	17.48	42.29	51.95	583.42	117.26
32.18	30.80	27.64	26.36	27.75	28.94	123.4	122.4	116.9	126.7	139.0	125.7	2.16	4.69	13.76	37.79	46.34	477.52	97.04
32.74	33.95	32.19	33.65	36.63	33.85	73.1	79.3	76.8	67.1	77.6	74.9	2.16	2.90	9.82	31.63	42.84	367.41	76.13
40.79	37.18	39.57	36.63	39.68	38.77	92.2	85.4	94.1	94.6	95.9	92.4	2.15	3.88	14.93	37.79	46.67	440.50	90.99
43.84	41.90	42.73	42.18	42.19	42.57	104.4	93.9	97.9	107.9	101.6	101.1	2.16	5.54	16.71	41.40	53.17	482.52	100.25
39.12	37.64	38.16	37.55	39.50	38.39	90.0	86.2	89.6	89.9	91.7	89.5	2.16	4.11	13.82	36.94	47.56	430.14	89.12

Arbiting figures of 2.16 in case of T1 (Control) instead of zero.

Monetary returns (Rs) for grain, stover, forage and their cumulative returns (Gross returns)

Varieties	Grain yield at the rate of Rs.150/q T1	T2	T3	T4	T5	VxS Mean	Stover yield at the rate of Rs.18/q T1	T2	T3	T4	T5	VxS Mean	Forage yield at the rate of Rs.18/q T1	T2	T3	T4	T5	T6	VxS Mean	Grain, stover and forage combined value T1	T2	T3	T4	T5	T6	Net returns (Rs
V_1S_1	6119	5495	6119	6119	6867	6142	1106	1106	1268	1178	1106	1153	39	45	156	462	800	6668	1362	7263	6645	7542	7758	8773	6668	865
S_2	6618	6368	6494	6867	7118	6693	1385	1353	1430	1367	1205	1349	39	45	285	653	809	7498	1555	8041	7770	8208	8887	9131	7498	959
S_3	6867	6618	7493	7242	7377	7119	1484	1358	1636	1394	1331	1440	39	103	303	740	896	7807	1663	8389	8078	9432	9376	9694	7807	102
Mean	6535	6160	6702	6743	7121	6652	1325	1274	1445	1313	1214	1314	39	64	248	618	865	7325	1526	7898	7498	8394	8674	9199	7325	949
V_2S_1	4869	5619	4869	5619	6119	5419	1196	1124	1189	1061	989	1108	39	55	216	629	773	6593	1384	6104	6798	6254	7309	7831	6593	791
S_2	6867	5744	6993	5870	6618	6418	1268	1151	1196	1232	1277	1225	39	81	252	725	884	7582	1594	8174	6975	8441	7826	8779	7582	923
S_3	6993	7118	7113	7118	6743	7018	1484	1259	1310	1484	1439	1401	39	84	285	734	950	7747	1640	8515	8460	8742	9335	9131	7747	100
Mean	6243	6160	6327	6202	6493	6285	1316	1176	1235	1259	1235	1244	39	73	251	696	869	7308	1539	7598	7411	7812	8157	8597	7308	906
V_3S_1	3746	4121	3497	3497	3497	3671	1663	2050	1708	1385	2095	1780	39	57	159	617	720	6578	1362	5448	6227	5363	5498	6312	4578	651
S_2	4869	4620	4320	3746	4121	4335	2329	2104	2243	2508	2697	2386	39	84	270	662	827	8706	1765	7237	6808	6982	5916	7645	8706	848
S_3	5868	5120	4620	4620	4869	5019	2670	2454	2341	2949	2715	2620	39	113	315	761	935	10501	2111	8577	7687	7245	8330	8519	10502	975
Mean	4828	4620	4146	3954	4162	4342	2221	2203	21[illegible]4	2281	2503	2262	39	84	248	680	834	8595	1746	7087	6907	6497	6915	7499	8595	835
xT																										
1	4911	5078	4829	5078	5495	5078	1322	1427	1382	1208	1396	1347	39	52	177	569	771	6613	1370	6272	6556	6387	6855	7662	6613	779
2	6119	5577	5936	5495	5952	5816	1660	1537	1693	1702	1726	1664	39	70	269	680	840	7929	1638	7817	7181	7898	7877	8578	7929	911
3	6576	6285	6410	6327	6329	6385	1879	1690	1762	1942	1828	1815	39	100	301	745	957	8685	1804	8494	8075	8472	9014	9114	8685	100
Mean	5869	5647	5725	5633	5925	5760	1620	1551	1607	1614	1650	1609	39	74	249	665	856	7743	1604	7528	7272	7581	7912	8431	7743	897