“Relative performance of maize hybrid under rainfed conditions of Jabalpur”

THESIS

Submitted to the

Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur

In partial fulfilment of the requirements for
the Degree of

MASTER OF SCIENCE

In

AGRICULTURE

(AGRONOMY)

By

ANKITA KATARE
Department of Agronomy

Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur

College of Agriculture

Jabalpur (MP)

2015

CERTIFICATE - I

This is to certify that the thesis entitled **"Relative performance of maize hybrid under rainfed conditions of Jabalpur"** submitted in partial fulfilment of the requirement for the degree of **"MASTER OF SCIENCE" in Agriculture (Agronomy)** of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur is a record of the bonafide research work carried out by **Miss Ankita Katare** under our guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instruction.

No part of the thesis has been submitted for any other degree or diploma (Certificate awarded etc.) or has been published/published part has been fully acknowledged. All the assistance and help received during the course of the investigations has been acknowledged by her.

Place : Jabalpur

Date : .

(**Dr. Girish Jha)**
Chairman
Advisory Committee

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

Chairman	**Dr. Girish Jha**	……
Member	**Dr. K. R. Naik**	……
Member	**Dr. Satrupa Rao**	……
Member	**Dr. R. B. Singh**	……

CERTIFICATE – II

This is to certify that the thesis entitled **"Relative performance of maize hybrid under rainfed conditions of Jabalpur"** submitted by **Miss Ankita Katare** to the J.N. Krishi Vishwa Vidyalaya, Jabalpur in partial fulfilment of the requirements for the degree of **"Master of Science in Agriculture"** in the Department of **Agronomy** has been after evaluation approved by the External Examiner and by the Student's Advisory Committee after an oral examination on the same.

Place: Jabalpur

Date: ……..

(Dr. Girish Jha)
Chairman
Advisory Committee

MEMBERS OF THE ADVISORY COMMITTEE

Chairman	**Dr. Girish Jha**	……
Member	**Dr. K. R. Naik**	……
Member	**Dr. Satrupa Rao**	……
Member	**Dr. R. B. Singh**	……
Head of the Department	**Dr. Girish Jha**	……
Director of Instructions	**Dr. G.S. Rajput**	……

Declaration and Undertaking by the Candidate

I, Shyam Lal S/o Shri Gopal Ram Certify the work embodied in thesis entitled “Efficacy of propaquizafop and imazethapyr mixture against weeds in soybean” is my own first hand bonafide work carried out by me under the guidance of Dr. M.L. Kewat at Department of Agronomy, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur and place during 2013-2014.

The matter embodied in the thesis has not been submitted for the award of any other degree/diploma. Due credit has been made to all the assistance and help.

I, undertake the complete responsibility that any act of misinterpretation, mistakes, errors of fact are entirely of my own.

I, also abide myself with the decision taken by my advisor for the publication of material extracted from the thesis work and subsequent improvement, on mutually beneficial basis, provided the due credit is given, thereof.

Place: Jabalpur

Date: **Shyam Lal**

Copyright Transfer Certificate

Title of the Thesis – Efficacy of propaquizafop and imazethapyr mixture against weeds in soybean

Name of the candidate – Shyam Lal

Subject – Agriculture

Department – Agronomy

College – College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh

Year of thesis submission – 2014

Copyright Transfer

The undersigned Shyam Lal assigns to the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur Madhya Pradesh, all right under Copyright Act, that may exists in and for the thesis entitled “Efficacy of propaquizafop and imazethapyr mixture against weeds in soybean” submitted for the award of M.Sc. (Ag.)

Date:

Place: Jabalpur

Dr. M.L. Kewat **(Shyam Lal)**

Major Advisor **Student**

ACKNOWLEDGEMENT

First of all I would like to thanks to almighty god for giving me this opportunity to express my heartfelt gratitude to all the dedicated people whose support kind co-operation encouraged me during the course of investigation.

I avail this unique opportunity in expressing my sincere and deepest sense of gratitude to my respected guide and Chairman of my Advisory Committee Dr. Girish Jha Professor and head of the Department, Department of Agronomy JNKVV, Jabalpur for his genius guidance, valuable suggestions, constant encouragement, constructive criticism and sustained interest throughout the entire period, which resulted in the completion and presentation of this thesis.

With profound respect, I wish to express my sincere gratitude to all venerable members of my advisory committee, Dr. (Smt.) Satrupa Rao, Professor and head of the Department, Department of Plant Phisiology, Dr. K..R. Naik Principal scientist, Department of Agronomy, College of Agriculture, Jabalpur, Dr. R.B Singh Professor, Department of Mathematics and Statistics, College of Agriculture Engineering for their valuable guidance, generous advice during the course of investigation.

I Sincerely express my thanks to Prof. V. S. Tomar, Hon'ble Vice Chancellor, JNKVV, Jabalpur, , Dr. S. K. Rao, Dean Faculty, JNKVV, Jabalpur, Dr. S. S. Tomar, Director of Research Services, JNKVV, Jabalpur, Dr. Om Gupta, Dean, College of Agriculture, Dr G. S. Rajput Director of Instruction, Dr. V. K. Pyasi, Dean Students Welfare, JNKVV Jabalpur for providing me all necessary facilities during the research work.

I am deeply indebted to express my sincere thanks to my teachers, Agronomy, Dr. M. L. Kewat, Dr. V.K. Shukla, Dr. K. K. Agrawal, Dr. J.K. Shrama, Dr. S.K. Viswakarma, Dr. A. K. Jha, , Smt. Nisha Sapre Smt. Arti Shrivatava, Miss. Monika Soni and other staff members of Department of Agronomy, for their helping attitude during the experiment and course work accordingly.

I express my sincere thanks to my seniors. Space does not allow extending my affection and appreciation to my friends, Susmita, Ankita, Bheem, Kapil, and my juniors Asma and Priya.

Words are not enough to express my heartiest feelings of humble gratitude and profound sense of appreciation to my beloved and respected parents Shri A. B. Katare and Smt. Rita Katare and loving Brother Palash katare, and all my family members whose constant inspiration, devotion, blessing and untiring efforts brought me to success.

Place: Jabalpur **(Ankita Katare)**

Date:

CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATION

Legends		Description
Abst.	:	Abstract
Ann.	:	Annual
Agri.	:	Agriculture
Agro	:	Agronomy
ANOVA	:	Analysis of variance
B : C	:	Benefit cost ratio
C.D.	:	Critical difference
CGR	:	Crop growth rate
DAS	:	Days after sowing
d.f.	:	Degree of freedom
dS/m	:	Desi siemen per meter
EC	:	Electrical conductivity
et al.	:	Alied (and other)
Fert.	:	Fertilizer
Fig.	:	figure
G	:	Gram
HI	:	Harvest index
/ha	:	Per hectare
i.e.	:	That is (in reference to)
j.	:	Journal
K_2O	:	Potassium
Kg	:	Kilogram
L	:	Liter
LA	:	Leaf area
LAI	:	Leaf area index
Max.	:	Maximum
M	:	Meter
min.	:	Minimum

Mm	:	Millimeter
NAR	:	Nate assimilation rate
No.	:	Number
P_2O_5	:	Phosphorus
/	:	Per
Q	:	Quintal
Res.	:	Research
RH	:	Relative humidity
Rs	:	Rupees
Sci.	:	Science
SE (m) $\pm$	:	Standard error of mean
RGR	:	Relative growth rate
SMW	:	Standard meteorological week
Sco.	:	Society
S.S.	:	Sum of square
Viz.	:	Wide list
@	:	At the rate of
^oC	:	Degree Celsius
%	:	Percentage

INTRODUCTION

Importance of any crop can be judged by its area, production, utilization and share in trade. The same criteria or standard can be valid for maize to judge its importance as cereal crop.

Maize (*Zea mays* L; 2n=20) belongs to family poaceae and grown as multipurpose crop in the world. It is well adapted to subtropical, tropical and temperate regions of the world. It possesses a remarkable diversity of vegetative types having a wide range of ecological adaptation. The unique energy capturing capacity and efficient use of CO_2 as C_4 plant have made it capable of producing maximum grain yield per unit area as compared to all other cereal crops.

Because of its short life cycle and possibility of growing two or more crops in a year and maize is incorporated in various cropping systems. Studies carried out under various soil and climatic conditions under All India Coordinated Research Project on Cropping Systems revealed that compared to existing cropping systems like rice-wheat and rice-rice, maize based cropping systems are better user of available resources and the water use efficiency of maize based cropping systems was about 100 to 200% higher at different locations.

It is a major cereal crop and emerging as third most important crop in India after rice and wheat. Maize is having special significance because in addition to staple food for human being and quality feed for animals, it serves as a basic raw material as an ingredient to thousands of industrial products that includes starch, oil, protein, alcoholic beverages, food sweeteners, pharmaceutical, cosmetic, film, textile, gum, package and paper industries etc. It provides the nutritional security as it contains 72% starch, 10% protein, 4.8% oil, 8.5% fiber, 3% sugar and 1% ash. (Chaudhary,1983). Due to its high yielding potential, it is called queen of cereals.

It is grown in 8.26 million hectares in India with the production of 16.72 million tones and productivity of 2024 kg/ha. In Madhya Pradesh it is grown in 0.83 million hectare with the production of 1.05 million tones, and productivity of 1256 kg/ha (Anonymous 2011)

It is used as a staple food; several food dishes including “Chapaties” are prepared. Green cob are roasted and eaten by people with great interest. Maize is an important raw material and more than 3000 products have been made by using maize directly/indirectly provides large opportunity for value addition.

Thus, the father of green revolution, the renowned Noble Laureate, Dr. Norman E. Borlaug, believes that “After the last two decades saw the revolution in rice and wheat, the next few decades will be known as maize era”.

It is a solution for emerging problems of depleting water table, labour shortage, low farm profitability, food security and climate change to make it as an alternative crop for the diversification and livelihood security due to its various types and uses.

At present yield level is much lower than the potential of our existing varieties. Main constraints to enhance maize productivity are suboptimal plant density, imbalance fertilizer use, inadequate drainage and irrigation, weed infestation, insect-pest problems and the selection of unsuitable cultivars under a given set of environments.

Adoption of high yielding suitable hybrids not only improves the grain yield and its quality but also leads to higher income per hectare as compared to conventional varieties of maize (Abbas,2001). Modern maize hybrids have greater potential as compared with older hybrids (Russel, 1986). Nazir et al. (2006) stated that maize hybrids usually have high yielding potential than open pollinated varieties due to hybrids vigour.

Since the yield potential of our existing varieties is deteriorating day by day, so the selection of better varieties with high potential and wide range of adoptability is highly essential and tolerance to biotic and abiotic stresses.

The likely cause for high yield in modern hybrids has been more cob bearing plants per unit land area without reduction in grain per cob.

Hybrid maize under optimum crop production, nutrient management and plant protection can produce economically more yield as compared to composite and open pollinated varieties. Olakajo and Iken (2001) reported that maize varieties produce significantly different yield at different locations. Olaoye (2009) emphasized the need to evaluate maize varieties in various agro-ecological zones for their adaptation, yield potential and disease reactions so as to release suitable varieties for cultivation on farmer's fields. It is, therefore, imperative to understand the relationship among yield testing locations for better adaptation of germplasm to different production environments (Threthowan et al., 2001). Keeping this in view, the present study was therefore, designed to compare the production potential of different available maize hybrids, an experiment entitled "Relative performance of newly developed maize hybrids for growth, yield attributing traits and yield in vertisol under Kymore plateau and Satpura hills zone" was conducted at Research Farm, JNKVV, Jabalpur during kharif 2014, with the following objectives:-

1. To find out the suitable maize hybrids in vertisol under rainfed condition
2. To assess the nutrient uptake of different maize hybrids
3. To determine economics of the treatments

REVIEW OF LITERATURE

There are enormous literatures available supporting the different aspects of agronomic management of maize hybrids. New hybrids are coming forward for different agro-climatic conditions of India as well as of Madhya Pradesh. In this chapter, an attempt has been made to present the review of the available literatures under the relative performance of maize varieties

Effect on plant growth parameters

Shah *et al.* (1982) reported that the Indiana 690 produced heavier kernels than South Dakota 604 under Islamabad conditions.

Mascagni *et al.* (1995) found in field trials near St. Joseph, Louisiana, 9 maize hybrids ranging in maturity from 88 to 123 days, the grain yields from late maturity cultivars were higher than early maturing cultivars.

Kurdikeri *et al.* (1998) conduct a field experiment in Karnataka to study the influence of seed size on field performance in maize hybrids (Zea maize L.) he is taking 5 maize cultivars found that the grain yield was not significantly affected by seed size (7.5-11 mm, 7.0-7.5 mm or 6.75-7.00 mm).

Kumar and Singh (1999) reported that the grain weight per cob and grain yield/ha were positively correlated with physiological parameters such as LAI, LAD, CGR, NAR and plant nitrogen content.

Sankar *et al.* (2002) found significant correlation among the three crop growth parameters was observed for all cultivars, except between dry weight and grain yield for Ashwini. The first principal component of the fresh and dry weight and grain yield indicated more than 90% of variation in crop growth for all cultivars except Ashwini and Megha. HGT-3 recorded the highest mean dry and fresh weights, while Trishulata produced the highest mean grain yield over the 8 seasons. HGT-3 and African Tall gave high mean and standard deviation for all the three traits studied. Principal component analysis based on values derived for the evaluated traits revealed that HGT-3 was superior among the cultivars.

Hussain *et al.* (2003) evaluated fourteen maize varieties for grain yield at agriculture research institute D.I.Khan during 2001. Analysis of variance revealed that maize cultivars differed significantly for days to 50% silking, plant height. The tallest plant height of 217 cm was obtained in YHD-555 and P-3060, while dwarfest plant height in NC-2006 and EV -1098. Plant height had a positive relation with grain yield. P-3060, Hybrid-3, YHD-555 and P-3012 have great yield potential and are expected to stabilize maize yield therefore these cultivars were recommended for general cultivation under agro ecological conditions of D.I. Khan.

From the 5 years field experiment of yield performance and stability of different maize hybrids, Porto and Storck (2003) were classified each hybrid by comparing its yield average of all hybrids. AG 6018, P 30F33, P 30K75, DKB 215 and DKB 344 were indicated for intermediate environments; AGN 2012, AGN 3150, BRS 3060 and P 30R07 were indicated for higher than intermediate environments; and AG 5011, G800 and P 3063 were indicated for all environments.

Yakadri and Rao (2003) found two genotypes MRC 3 and 8 maintained high RGR (0.11-0.12 g g-1 day-1) between 45 and 60 days after sowing (DAS). Three genotypes MRC 3, 8 and 13 recorded high LAR values between 30-45 and 75-90 DAS. MRC 8 with superior LAR recorded the maximum 100-seed weight (31.3 g) and seed yield (24.68 q/ha) due to its high photosynthetic efficiency. All the three genotypes (MRC 3, 8 and 13) with promising physiological parameters can be utilized in breeding programmes to evolve better genotypes.

Khalil et al. (2005) EV-5098 gave the highest grain yield (7040 kg/ha) and ear height (80 cm). NC-2002 gave the earliest days to silking (61) while Pacific-993 showed maximum plant height (194 cm).

Sorte et al. (2005) found that the maximum plant height was attributed by composite YMC 003. Composite YMC 9902 was the earliest in 50% flowering (tasselling and silking) and maturity; whereas YMC 9901 was late. The overall observations at four growth stages (45, 60, 75 and 90 days after sowing) indicated the highest dry matter production with maximum leaf

area in composite YMC 9905 followed by NAC 6004. The highest relative growth rate, net assimilation rate, leaf area ratio and crop growth rate were computed during flowering stage (45-60 DAS) which was then declined at cob development, grain filling and maturity period. Composite YMC 9905 was superior in growth parameters and exhibited the highest grain yield (58.33 q/ha).

Pooja and Singh (2008) observed that the inbred line YHP-A (P3) was found to be well adapted to all the environments while Fob 446 (P2) was found to be specially adapted to low input environment for both grain yield and days to 50% silk emergence. The hybrids namely P1 x P2, P2 x P3, P3 x P5 and P4 x P5 were found to have grain yield higher than the mean value and well adapted across the environments.

Malik et al. (2009) reported that the variety Soan -3 (149 cm) was shortest and hybrid 30-K-95 (202.3 cm) was the tallest among all the varieties and hybrids.

Singh et al. (2009) identified the hybrid combinations 'L2' x 'T3' and 'L22' x 'T2' were found to be stable across environment, whereas 2 hybrids 'L11' x 'T1', 'L16' x 'T1' were found suitable for irrigated environments for grain yield. For moisture stress environment five crosses 'L2' x 'T3', 'L3' x 'T2', 'L15' x 'T1', 'L19' x 'T2' and 'L21' x 'T3' were found stable for grain yield. For days to maturity only one hybrid 'L7' x 'T3' was found stable across environment.

Vieira et al. (2009) studied that the hybrid from C and K inbreds presented better indexes for grain yield and popping expansion. About diseases, the hybrids from the L, H and K inbreds showed greater resistance levels to Southern rust, and hybrids from G inbred had better Northern leaf blight resistance. Hybrids from L and M inbreds showed better phaeosphaeria leaf spot resistance.

Akram et al. (2010) found maximum leaf area index and crop growth rate was found 60 days after sowing and after that it declined towards harvest.

Kumar (2010) reported that the double cross [(CM 601-S4-2-3) x (CML-107)] x [(CML-107)] x [(CML-83)] x [(Pop 34-C5-HC-86-2-1#(x) 5-b)] predicted better for most of the characters viz., earliness in 50 percent silking

and maturity, short plant and ear height, longer and thicker ears, average 500 kernel weight and number of kernel rows, short vegetative growth, medium grain filling and average grain moisture content. Similarly the second top ranking double cross [(M9 x CM-601)-(x)-(S4-1) x (Pop 30-C3-P5-83)] x [(CML-3) x (CML-117)] was also expected to perform better for most of the desirable traits.

Hussain et al. (2011) Variety Ev-5098 had the highest grain yield of 7.35 t ha^{-1}. Variety Islamabad White took more days to pollen shedding and silking while variety Soan-3 was found early maturing, which took 69 days to 50% silking. The highest plant height of 205 cm was noted in variety Sahiwal-2002.

Ijaz et al. (2011) show that both the promising hybrids of Yousafwala hybrids (hybrid YH-1921and YH-1898) have wider adaptability in both the seasons and are nearly at par in yield with the commercial hybrids (32 F-10, 34 N-43, 8288).

Mahajan et al. (2012) conduct a field experiment in Directorate of Maize Research, Pusha Campus, New Delhi to study the performance of nineteen maize single cross hybrids were evaluated in northern India under severe cold stress in natural conditions during rabi 2010-11. Vivek Hybrid 9, Vivek QPM 9 and JH 3459 in early/extra-early maturity, HM 9 in medium maturity and HM10 and Seed Tech 2324 in late maturity group are suitable for sowing in the winter season. Yellowing of leaves caused by cold spell proved to be an important parameter to judge cold tolerance at vegetative stage.

Nepaliya et al. (2012) concluded that the higher number of plant per unit area and height were recorded for HQPM-1 which is significantly superior to all other varieties.

From the experiment conducted at Udaipur, Parihar (2012) found that the Hybrids exhibited higher grain yield per plant and low chlorophyll stability index in stress condition, were found good for stress environments.

Sivalakshmi et al. (2012) observed DHM-117 being at par with local checked recorded significantly taller plant with more dry matter per plant.

Effect on yield attributes and yield

Malhi et al. (1993) observed that the single hybrids had a significantly higher ranking than the double ones for yield on average over all crosses and over the 5 best crosses. Out of 10 sets of related single and double crosses, 5 sets showed significant differences between the grain yield of the single and double hybrids. Comparison of results from 2 test sites indicated that the single hybrids were more stable than the double ones in performance. With the available germplasm, it is expected that single hybrids would out yield double ones by 7-9%.

Bolanos (1994) observed the hybrids consistently out yielded than open pollinated varieties by 1.0-1.5 t/ha across all the environments. The basis for such differences seemed to rely on the higher daily ear growth rate of the hybrids (2.7 g/day) than of the Open pollinated varieties (2.3 g/day). Consistent with this data, he resulted that hybrids have a higher harvest index than Open pollinated varieties.

Murariu et al. (1994) found that the dry matter yields of maize silage hybrids Turda 200, Turda 215, Fundulea 270, Eva, Carla and Panonia ranged from 15.58 t/ha in Turda 200 to 18.49 t in Panonia in chernozem soil.

Babu et al. (1996) found that the Ksheeramrutha was quick growing, leafy, tall and high yielding compared with the other genotypes tested. It produced good quality fodder, had high protein content and performed well in mixtures with black soya and cowpeas.

Ignat et al. (1996) tested several maize hybrids, released at the Research Institute for Cereals and Industrial crops Fundulea, as the second crop after the winter barley in Moara Domneasca, Romania, under irrigation, on a typical brown-redish soil during 1985-94. The grain hybrids belong to the FAO maturity group 100-200, while the hybrids for forage to the FAO maturity group 400-500. The average grain yield (with 15.5% moisture) of the hybrids from the FAO maturity group 100-200 was 7800 kg/ha. The average yield of dry matter of the hybrids for forage was 22 000 kg/ha and those for direct consumption yielded 20 000 kg/ha.

Field trials were conducted between 1995 and 1997 on a brown luvic soil in Livada, Romania by Cords (2000) to evaluate the yield of 7 registered and 4 unregistered maize hybrids. Montana was used as the control. The hybrids exhibited high yield potential, with mean grain yields of 10034, 9263 and 10154 kg/ha in 1995, 1996 and 1997, respectively. The hybrids Helga, HTT 167 and Doina, which exhibited similar vegetation periods with that of the control (Montana), gave high and stable yields and exhibited resistance to lodging.

Maziya-Dixon et al. (2000) reported that the Hybrid 8644-31 had relatively high test weight, thousand kernel weight, hardness index, percent protein and crude fiber values then rest of maize hybrids.

Prado and Filho (2000) were evaluated twenty maize hybrids under conditions of late sowing in quartzose low fertility sand of the savanna of the Triangulo Mineiro, Brazil concluded that the hybrid DINA170, XL380 and RA200 showed the best yield, with productivity gains of 22.9, 17.9 and 9.7%, respectively; as compared to the regional control BR201.

Kumar et al. (2002) found that the early composite produce significantly taller plants compared to hybrids which were statistically at par with other. The yield attributes like no. of cobs, grain/cobs and 1000 grain weight were significantly superior in maize hybrids to composite. All hybrids gave significantly higher yield (34.98 - 61.66) over composite. Among hybrids KH - 517 gave highest yield being 7.78, 19.76, and 61.66, as well as the harvest index (48.2) higher than PSCL 3436, KH101 and early composite respectively.

According to Hussain et al. (2003) the maize cultivar P-3060 produced the height grain yield of 11.92 t/ha where as the lowest yields 3.63 t/ha was produced by EV-1098. The cultivars P-3060, Hybrid-3, YHD-555 AND P-3012 produced grain yield higher than control by 105.88, 75, 56 and 55 percent respectively.

Jyoti et al. (2006) concluded that the performance of DMB101 x DMB109 was better in both (Delhi and Karnal) locations. On the basis of various parameters, 6 additional potential hybrids (DMB103 x DMB104,

DMB103 x DMB110, DMB105 x DMB109, DMB107 x DMB109, DMB102 x DMB109 and DMB103 x DMB109) were identified for further multilocation evaluations.

Singh and Singhi (2006) observed 'PEHM 2' recorded higher grain (0.34 t/ha) and stover (0.50 t/ha) yields compared to 'PEHM 1' (0.29 and 0.43 t/ha, respectively).

Jogdand et a*l*. (2008) reported that the hybrid PMH-19 among PMI-27, PMI-28, PRO-4640, and MMH-3816 gave the highest value of grain, fodder and biological yield.

Tahir et al*.* (2008) resulted that the maximum number of grain per cob, maximum 1000 grain weight and ultimately maximum grain yield was obtain in maize hybrid HG-3740 at local condition of Faisalabad, Pakistan.

Jadhav and salke (2009) found that kargil recorded significantly higher grain yield (68.5 q/ha) than parbhani sakti (59.31q/ha). The net monetary returns and benefit cost ratio also higher for ‘kargil’ maize hybrid.

Malik et al*.* (2009) reported that the hybrids NT-6622(7842kg/ ha) and NT-6651 (7759 kg/ha) ranked top and second in grain yield. The hybrid P-30-25 produced the maximum number of grains per rows (51) and Grast -8288 produces the lowest (29). 1000 grain weight ranges from 23g to 39 g.

Pal and Bhatnagar (2009) conduct a field experiment at Crop Research Centre, GB. Pant University of Agriculture and Technology, Pantnagar to evaluate the performance of different maize hybrids and composites in Tarai region of Uttarakhand. Hybrid Vivek-15 gave highest cob yield (12 t ha-1), grain yield (6.5 t ha-1), among the composites, Kanchan, Tarun and Navin gave higher grain yields than other composites.

Singh et al*.* (2009) identified the hybrid combinations 'L2' x 'T3' and 'L22' x 'T2' were found to be stable across environment, whereas 2 hybrids 'L11' x 'T1', 'L16' x 'T1' were found suitable for irrigated environments for grain yield. For moisture stress environment five crosses 'L2' x 'T3', 'L3' x 'T2', 'L15' x 'T1', 'L19' x 'T2' and 'L21' x 'T3' were found stable for grain yield. For days to maturity only one hybrid 'L7' x 'T3' was found stable across environment.

Akram et al. (2010) found the response of hybrid Pioneer 32B33 was better with respect to growth and yield as compared to Dekalb 979.

Singh and Chauhan (2010) analyzed the genetic and physical standard and influence of location on some hybrid maize variety namely Vivek hybrid 5, Vivek hybrid 9, Vivek hybrid 11, Vivek hybrid 15 and Vivek hybrid 23 on the basis of quantitative characters. Genotype Vivek hybrid 23 was found the highest production potential with null affect by the location.

The higher grain yield was attributed to greater cob length, cob girth, cob weight and fodder yield of maize cultivars. Composite Shweta recorded the lowest growth and yield attributes, grain and fodder yield and net return values.

Aziz et al. (2011) studied performance of BARI hybrids at three different location and they found that the BARI hybrids maize-5 produce maximum grain yield at all 3 locations. So BARI hybrid maize-5 might be suitable for cultivation in hilly areas of Bangladesh.

Biradar et al. (2011) evaluated that the hybrid EH-434042 recorded higher fodder yield and grain yield, while KHHM-110 recorded lesser fodder and grain yield.

Maize varieties EV-5098 and Sahiwal-2002 were found most promising, which have the potential to increase the average yield (5.26 to 7.35 t /ha) of maize in Dera Ismail Khan and are therefore recommended for general cultivation reported by Hussain *et al.* (2011).

The hybrids belongs to late group evaluate as higher yielding capacity of dry biomass as compared to the maize hybrids from the mid-late group. The highest-yielding and promising hybrid in the mid-late group was Kn-517, the yield of which was 18243,3 kg/ha, and in the late hybrid group Kn-683A with biomass yield equaling to 20340,0 kg/ha. The mentioned two hybrids are the most suitable for cultivation under the conditions of the Pleven region for forage biomass production reported by Kertikova *et al.* (2011).

Khalil et al. (2011) concluded that ICI-974 and Pioneer-3025 are stable hybrids at Nowshera, Mansehra and surrounding areas North West Pakistan.

Khalil et al. (2011b) on the basis of average grain yield across locations as ICI-974 (8439 kg ha-1) and Pioneer-3025 (8310 kg ha-1) outclassed all other hybrids. The GGE biplot analysis ranked hybrids on above average grain yield across locations as ICI-974 was best followed by Pioneer-3025 and Hi-Corn, while rest of the hybrids produced grain yield below average. Across all locations GGE biplot identified ICI-974, Pioneer-3025 as the most stable hybrids for stability of performance.

The hybrid entry number M0826-2 recorded the highest grain yield in Lokodisa, while entry M0826-9 had the highest grain yield in Sabongari. The combined results however, indicated that the entries M0826-2, M0826-6, M0826-7, M0826-9, M0826-13 and M0826-14 recorded among higher grain yields compared to other entries reported by Izge and Dugje (2011). Most entries which gave higher grain yields incidentally produced higher values of 1000-grain weight. In the same vein, entries having higher grain yields also flowered earlier and could have an inherent potential for early maturity, a trait highly desirable for rainfall marginal areas.

Gangwar et al. (2012) found that the maize hybrids DKC8101 with planting geometry of 60x20cm and fertility level 150:75:50 NPK kg/ha produced significantly higher grain yield of 6.78 t/ha and maximum seed index 26 g/100 seed in comparison to rest of combinations.

Nepaliya et al. (2012) reported the hybrid hqpm-1 outyielded than all other varieties significantly by producing 3715 kg/ha as well as by producing 5269 kg stover/hectare.

Among the good general combining inbreds with high per se performance for grain yield was P7 and P12. Among the hybrids, P9 x P12 and P4 x P12 were found best for all the environments but P10 x P12, P1 x P7, P1 x P4 were best only in well irrigated environments reported by Parihar (2012).

Saqib et al. (2012) reported that the hybrid SIPRA-4444 produced maximum grain yield (6.02 t /ha) as compared to TS-13 (5.80 t/ha).

Sivalakshmi et al. (2012) observed DHM-117 being at par with local checked in cob length, cob girth, number of rows per cob number of seeds per row and seed weight than remaining genotypes.

A field experiment was conducted by Sobhana et al. (2012) at Indian agricultural research institute, New Delhi shows that 'HM 4' was a better baby corn hybrid *(Zea mays* L.) than PEHM 2 as it had early cob initiation, produced more and heavier cobs and recorded higher cob yield .

Effect on soil chemical properties and nutrient uptake by maize hybrids

Empig and Zuno (1984) observed under the irrigated test SMC 101 hybrid is efficient in nitrogen utilization and tolerant to low levels of phosphorus fertilization and in the rainfed tests, SMC 301 was more efficient than SMC 102 and SMC 201 in all nitrogen levels. Furthermore, the tests showed that 40 kg P/ha is the most economical rate for the three hybrids.

Mishra (1993) conduct a field experiment on loamy soil during the rainy season of 1987-88 at Sidhi (MP). Maize cv. Ganga 5, Ganga safed 2 and Sathi were given no fertilizer, 50kg Nitrogen+30 kg P_2O_5 +40 Kg K_2O or 1.5 or 2 times these N,P and K rates. The highest grain yield with the highest NPK rate in all the cultivars averaged across the fertilizer rate, Ganga 5, Ganga safed 2 and Sathi gave grain yield of 1.48,1.25,and 1.11 t/ha, respectively.

Tollenaar (1994) observed mean grain yield of four hybrids across 3 year was 65% higher in the high-N, weed-free treatment than in the low-N, high-weed-pressure treatment. The effect of weed interference on maize grain yield was greater at low than at high N. Maize hybrids responded differently to N level and weed interference; the yield of the old hybrid was reduced more by low N and weed interference than yields of the new hybrids.

Shanti et al. (1997) conducted an field experiment at Rajendranagar, Hyderabad, during kharif 1993 to study the performance of newly released DHM107 with Varun at 5 levels of nitrogen application (0, 40, 80, 120 and 160 kg/ha). A total of 13 yield components were measured. As expected application of 160 kg N/ha gave the highest yields, with greater yields in DHM107 than in Varun. Genotype x N interaction was non-significant.

Padmaja et al. (1999) found that the DHM-107 had greater N, P and K uptake compared to the other maize cultivars. N at 150 kg/ha produced maximum N, P and K uptake by the crop.

The maximum grain yield per plant was recorded by the cross Prabhath-1 x UMI 492. The cross, which included UMI 760 and Prabhat-1 as parents, showed significant increase in grain yield, plant height, number of grain rows per cob, cob weight and starch content reported by Geetha (2000).

Sobhana et al. (2012) at Indian agricultural research institute, New Delhi found the two hybrids HM 4 and PEHM 2 did not differ in terms of N, P and K concentration in cobs or fodder.

Effect on economics

Tollenaar (1994) observed the mean grain yield of four hybrids across 3 year was 65% higher in the high-N, weed-free treatment than in the low-N, high-weed-pressure treatment. The effect of weed interference on maize grain yield was greater at low than at high N. Maize hybrids responded differently to N level and weed interference; the yield of the old hybrid was reduced more by low N and weed interference than yields of the new hybrids.

Kumar et al. (2002) conducted an experiment to find out the suitable maize varieties and the fertility requirement under rainfed condition of Himachal Pradesh. The net return (Rs 20951/ha) and Benefit cost ratio was (3.03) maximum from hybrid KH517 followed by PSCL 3436.

Thakur et al. (2003) concluded by the experiment AICRP on Dryland Agriculture, JNKVV College of Agriculture, Indore (M.P.) that the rainfed maize varieties grown in vertisol the grain and stover yield increased by 9.4 and 5.6%, respectively, due to earthing. Navjot recorded the highest grain yield (3975 kg/ha), net return (Rs. 11 584/ha) and benefit: cost ratio (2.20), closely followed by JM-12 with a grain yield (3830 kg/ha), net return (Rs 10 858/ha) and benefit-Cost ratio of (2.10).

Singh and Singh (2006) observed 'PEHM 2' also recorded higher values of net returns (Rs 18 422/ha) and benefit-cost (B: C) ratio (1.72) over 'PEHM 1', with net returns of Rs 14656/ha and benefit-cost ratio of 1.42.

Jadhav and Salke (2009) found that maize hybrid kargil recorded significantly higher net monetary returns and benefit cost ratio than Parbhani sakti.

Pal and Bhatnagar (2009) concluded that the Hybrid Vivek-15 gave maximum net returns (Rs 38576 ha-1) and benefit: cost ratio (4.09) and in case of composites, Kanchan, Tarun and Navin gave higher grain yields, net returns and benefit: cost ratio than other composites in Tarai region of Uttarakhand.

Karim et al*. (*2010) reported under Bangladesh conditions the average yield of hybrid maize was found higher than the national average. The average gross margin was observed to be Tk. 28456 on total variable cost basis. The cost per kilogram of maize cultivation was Tk. 4.12 and return from one kilogram of maize production was Tk. 7.80.

Pal and Bhatnagar (2012) found that the hybrid 'Him-129' proved more productive and profitable than pop corn 'VL Amber' and composites 'Pragati' and 'Vivek-11' in Mollisols of Uttarakhand.

The maximum net income of Rs. 114172 and benefit to cost ratio of (2.37) was obtained when the hybrid SIPRA-4444 was shown on 60 cm spaced ridges reported by Saqib *et al.* (2012).

MATERIALS AND METHODS

The experiment entitled “Relative performance of newly developed maize hybrids for growth, yield attributing traits and yield in vertisol under Kymore Plateau and Satpura Hill Zone” was conducted in kharif season, 2014 at Product testing unit Department of Agronomy, JNKVV, Jabalpur. This investigation required use of several techniques and materials on the farm as well as in the laboratory, which are systematically elucidated in this chapter. Several analytical works were also performed in the laboratory of Department of Agronomy, JNKVV Jabalpur. Beside the effect of different treatment tested under present investigation, several environmental factor viz. soil and weather conditions also exert their marked influence on the growth, development and yield of crop. Therefore soil properties of experimental field and weather conditions prevailed in the locality during the course of the investigation are also described in this chapter under appropriate heads.

Site of Experiment

The present experiment was laid out at Product testing unit Department of Agronomy, JNKVV Jabalpur (M.P.) during kharif, 2014. The topography of field was uniform with gentle slope and adequate research facilities viz. irrigation water, seeds, fertilizers, equipments and labours etc. were available on the research farm to conduct the field research observations smoothly.

Location and Climate

Jabalpur is situated in the central part of Madhya Pradesh at 23^0 91’ North Latitude, 79^0 58’ East Longitudes with an altitude of 411.78 meters above the mean sea level. The tropic of cancer passes through the middle of the district and semi arid and sub tropical climate with hot dry summers and cool dry winters. The average maximum temperature raised upto 46^0C and minimum temperature reaches as low as 6.8^0C. The average annual relative humidity is 74%. The average annual rainfall receives in this region is 1350 mm, mainly concentrated during the end of June to end of September through south-west monsoon.

Jabalpur lies in the agro-climatic zone classified as kymore Plateau and Satpura Hill Zone of Madhya Pradesh.

Table: 1. Weekly meteorological data during crop season (Kharif **2014)**

Month	Meteo. week	Temperature (^{0}C)		Relative humidity (%)		Sunshine hrs. (hrs/day)	Rainfall (mm)	Rainy days (No.)
		Max.	Min.	Mor.	Eve.			
June	22	42.3	26.6	46	17	10.4	0.0	0
	23	44.8	28.6	33	12	9.7	0.0	0
	24	39.8	26.4	64	37	6.2	37.0	3
	25	35.6	25.6	74	52	7.0	72.6	4
	26	36.5	26.4	65	38	4.5	9.8	1
July	27	34.5	26.1	71	41	6.5	296.8	3
	28	31.3	25.6	79	59	5.9	116.0	4
	29	32.3	24.5	90	79	3.2	117.5	6
	30	28.2	23.3	91	79	3.4	119.9	3
Aug.	31	26.3	24.6	92	79	2.3	32.4	5
	32	27.7	23.7	86	73	4.9	145.8	5
	33	28.2	24.0	86	63	5.0	101.8	2
	34	30.2	25.1	83	58	6.7	84.4	2
Sep.	35	31.9	24.2	88	65	7.8	3.0	2
	36	30.8	23.7	91	71	2.4	52.2	7
	37	30.7	23.4	91	72	3.8	87.4	6
	38	30.8	23.5	89	55	8.5	11.0	1
	39	31.9	21.6	85	41	10.0	0.0	0
Oct.	40	33.4	21.0	86	53	9.4	2.3	1
	41	32.4	20.4	88	55	8.4	0.0	0
	42	32.5	18.8	91	44	7.9	0.0	0
	43	31.6	16.6	89	41	8.8	0.0	0
	44	27.9	14.4	87	29	8.6	0.0	0
Total	**-**	**-**	**-**	**-**	**-**	**-**	**1289.9**	**55**

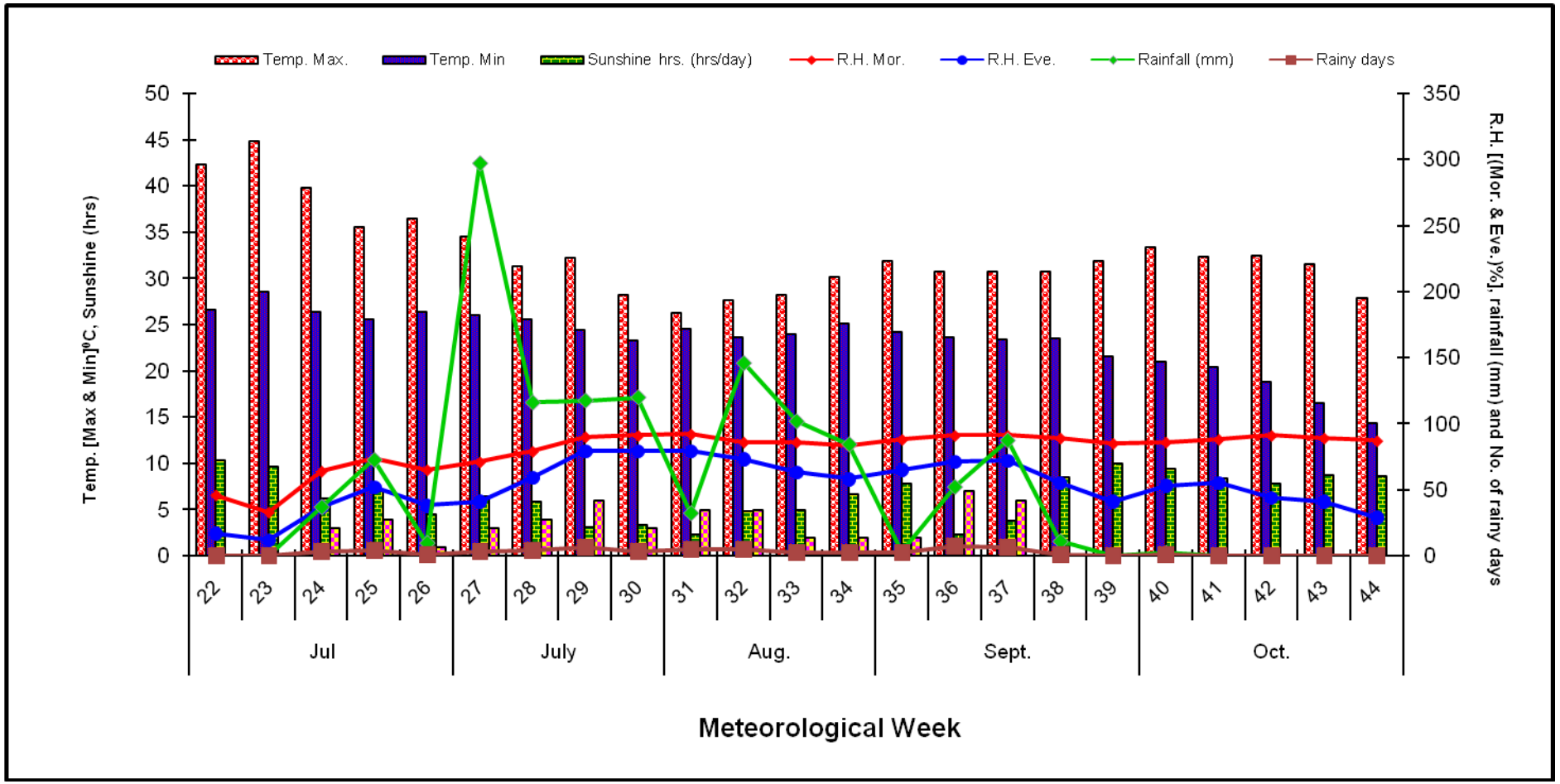


Fig. 1: Weekly meteorological data during crop season (*Kharif* 2014)

Weather conditions

Seasonal variations prevailing during growth period of crop play an important role in the development process, which may have great influence on the yield of crop. The weekly meteorological data pertaining to maximum and minimum temperature, relative humidity rainfall, no. of rainy days and sunshine hours during the crop season were recorded from the meteorological observatory, Agriculture Engineering College located at JNKVV Jabalpur (M.P.). These data are given in table 1, and graphically illustrated through the figure-1.

It is evident from the data that weather conditions were almost favorable for the growth and development of maize. The monsoon commenced in the first week of June and terminated in the first week of October. The total rainfall received during the crop season was 1289.9 mm, which was equally distributed in 39 rainy days from June to third week of September. Minimum and maximum mean temperature ranged from 14.4 ^{0}C to 44.8 ^{0}C, respectively. The relative humidity ranged between 33 to 92% in morning and 12 to 79% in evening. The mean sunshine hour varied between 2.3 to 10.4 hours per day.

Soil

On the basis of U.S. classification, the soil of Jabalpur is broadly classified as vertisol. It is characterized by deep and wide vertical cracks during summer and hot season. It swells when wetted and shrinks when dried. The soils of this region are black in colour with, medium to deep depth. The water retentions capacity of soils is good, but it favours to water logging under poorly drained conditions, particularly in semi deep lands coupled with high rainfall or free flooding conditions.

Soil properties of experimental field

In order to know the texture and inherent soil fertility status of experimented field, nine soil samples were collected randomly from 0-30 cm depth with the help of soil auger prior to start of the field experiment. These soil samples were then thoroughly mixed to get the composite sample. Requisite quantity of the soil from the composite sample was drawn and

subjected to analysis for physico-chemical properties of the soil as per standard methods adopted in the laboratory of Department of Agronomy, college of Agriculture, JNKVV, Jabalpur. The values recorded from the analysis are present in Table 2.

Table: 2. Physico-Chemical properties of the soil of the experimental field

Constituents	**Value**	**Class/ groups**	**Method used**
A. Mechanical composition			
Sand (%)	25.18	Clayey	International pipette method (Piper, 1967)
Silt (%)	19.18		
Clay (%)	55.64		
B. Chemical analysis			
Organic carbon (%)	1.50	Medium	Walkley and Black rapid titration method (Walkey and Black,1934)
Available nitrogen (kg/ha)	395.00	Medium	Alkaline permanganate method (Subbiah and Asija,1956)
Available P_2O_5 (kg/ha)	17.45	Medium	Calorimeter method (Olsen *et al.,* 1954)
Available K_2O (kg/ha)	301.00	High	Flame photometer method (Chapman and Pratt, 1961)
Soil pH (1:2.5 soil water ratio)	7.3	Neutral	Glass electric pH meter (Piper,1950)
Electrical Conductivity (ds/m)	0.31	Neutral	Solu-bridge method (Piper, 1959)

It is clear from the data given in Table 2 that the soil of experimental field was clayey in texture and neutral in reaction with neutral electrical conductivity and medium in available N, P and organic carbon and high in available K.

Cropping history of experimental field

The knowledge of previous crops on experimental field is essential to judge its productivity potential. The crop grown in the experimental fields during the past five years are presented in Table 3.

Table: 3. Cropping history of field before starting the present investigation

Year	Kharif	Rabi
2010-11	Soybean	Wheat
2011-12	Soybean	Wheat
2012-13	Maize	Wheat
2013-14	Maize	Wheat

Experimental details

Preparation of the Field

The experimental field was thoroughly prepared by tilling the land twice with tractors driven cultivators followed by two cross harrowing and leveling with the help of tractor driven leveler. Then the treatments were laid out on well prepared seed bed as per plan of layout (Figure-2) in the experimental field. The drainage channels (50cm wide and 20 cm deep) all around the plots were prepared to facilitate the removal of excess water from the experimental plots. The ridges and furrows are made manually by the help of kudali and spade to facilitate sowing of seeds and application of fertilizers.

Layout of the experiment

The experiment was laid out in randomized block design with seven treatments during Kharif 2014 in three replications. Plan of layout is given in Figure 2

Treatment details of the experiment

Seven treatments were laid out on well prepared seed bed in a randomized block design with 3 replications (Figure -2). The details of the treatments are given below:

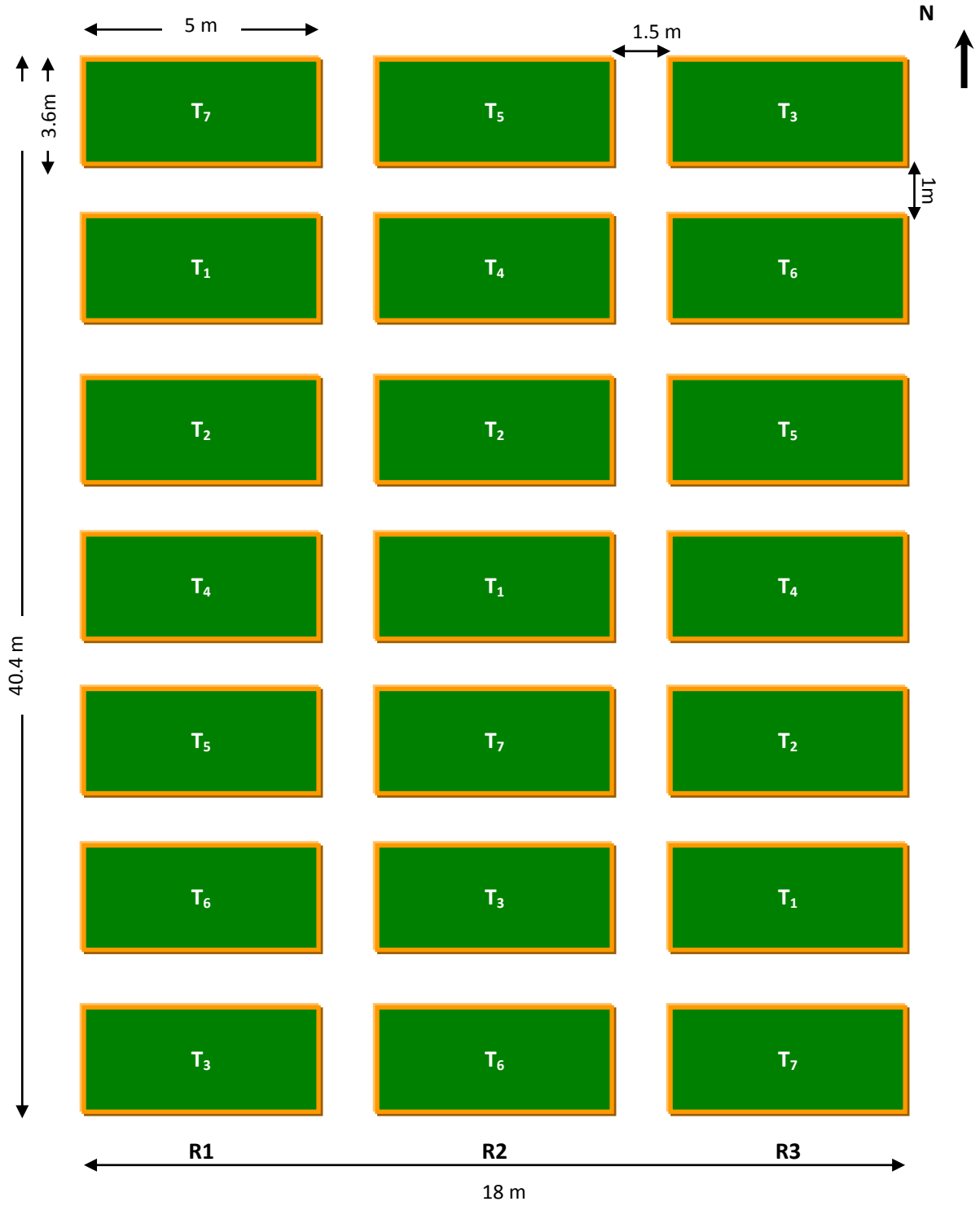


Figure: 2. Layout plan of the experiment

Treatments: 7 Maize Hybrids

T.No.	Treatments
T_1	JKMH 502
T_2	JKMH 1701
T_3	JKMH 4545
T_4	JKMH 4023
T_5	JKMH 4025
T_6	JKMH 4029
T_7	JK SURABHI

Design	:	RBD
Replications	:	3
Total number of plots	:	21
Gross plot size	:	3.60 m X 5.0 m
Net plot size	:	2.4 m X 4.0 m
Distance between replications	:	1.5 m
Distance between plots	:	1.0 m
Distance between rows	:	60 cm
Planting geometry	:	60 X 25 cm^2
Seed rate	:	18 kg/ha
Fertilizer dose (kg/ha)	:	120 Kg N, 60 Kg P_2O_5, 40 Kg K_2O
Date of sowing	:	11 July 2014
Date of harvesting	:	21 Oct 2014

Details of test crop and varieties

JKMH 502

It has distinguishing character like medium plant height upto 150-200 cm, higher grains per row, high protein content and stover yield is higher than other hybrids. It has semident type grain with yellow orange colour. It matures in 95-100 days. The 1000 grain weight nearly 300 g.

JKMH 1701

It has tall plant height upto 200- 250 cm. The grain rows per cob are upto 12-14 and has medium grain yield. It bears long ear with cylindrical in shape. It mature in 90-95 days and grain texture is semident.

JKMH 4545

It has distinguishing character like medium plant height upto 150-200 cm. It has the high cob girth upto12-15 cm. The colour of grain is yellow orange with semident texture and has 12-14 grain rows per cob.

JKMH 4023

It s high yielding cultivar with plant height upto 150-200 cm.The leaf blade is wide and diameter of >5 cm. The silk is of salmon colour and has the presence of anthrocyanin on silk. The cob is conical in shape and bears 14-16 grain rows per cob. The 1000 grain weight is >300 g. It matures in 85-90 days.

JKMH 4025

The plant height is medium with pigmented long ears with 12-14 grain rows per cob. The ear length is long, cylindrical in shape, having semident type yellow orange colour grain. It is early maturing variety. It has high protein content and high grain yield.

JKMH 4029

It has distinguishing character like presence of anthocyanin colouration of brace roots. It is high yielding variety with long cobs and high cob girth. The 1000 grain weight is >300 g. It is high yielding variety and matures early.

JK Surabhi

It is high yielding cultivar having plant height upto 200-300 cm, broad leaf blade (>9 cm), medium to large ear, large ear diameter (>5 cm), with cylindrical shape, having upto 14 grain rows. The hybrid matures in 85-90 days. The 1000 grain weight nearly >300 g.

Table 4. Details of different field operations done in maize during *kharif*-2014

S.No.	Operations	Date	Remark
1.	**Land Preparation**		
	i. Tilling (2 pass)	05/7/2014	By tractor
	ii. Harrowing (2 pass)	05/7/2014	By tractor
	iii. Leveling (1 pass)	05/7/2014	By tractor
2.	Lay out of experiment	07/7/2014	Manually
3.	Formation of ridges and furrows	09/7/2014	Manually
4.	Sowing and fertilizer application	11/7/2014	Manually
5.	1st weeding	3/8/2014	Manually
6.	First top dressing of N	5/8/2014	Manually
7.	Second weeding	29/8/2014	Manually
8.	Second top dressing of N	2/9/2014	Manually
9.	Application of insecticide	4/9/2014	By Knap shake sprayer
10.	Cob picking	21/10/2014	Manually
11.	Harvesting of plants	27/10/2014	Manually
12.	Shelling and winnowing	29-31/10/2014	Manually

Fertilizer and manure application

Nitrogen, phosphorus and potassium were applied @ 120, 60 and 40 kg/ha N, P and K, respectively in each plot. Total phosphorus and total potassium were applied as basal dose in all treatments. 50% nitrogen was applied as basal at the time of sowing, while 25% nitrogen as first top

dressing at knee height stage and remaining 25% nitrogen as second top dressing at tasseling stage

Sowing

The Seed were treated before sowing with the mixture of 2 g Thiram +2 g Carbendazim /kg seeds to avoid the possible occurrence of seed and soil born diseases starting from germination of seed to establishment of seedlings. The seed @ 18kg/ha was sown in all treatments by dibbing two seeds/hill in rows at intra row spacing of 25cm on 11 July 2014. These rows were opened at inter row spacing of 60 cm manually with the help of kudali.

Thinning and Gap filling

After complete germination, gap filling was done to maintain the desired plant population in the unit area the thing was done to maintain the desired plant population.

Water management

Since experiment was based on rainfed conditions, therefore, no irrigation was provided to the crop. However, bunds and channels were prepared around all the individual plots for storage of rain water and to check the nutrient movement from one to another plot and their loss and channels facilitate to drain out the excess water to prevent from water logging

Weeding, earthing and plant protection

The infestation of seasonal weed flora and their competition with the crop plants was started from very beginning due to early onset of monsoon. The dominant weed flora was *Echinochloa crusgalli, E. colonum, Cyprus iria, Commelina cummunis* and *Eclipta alba* etc. weeding done twice by manual first after 25 DAS and 50 DAS after germination for controlling the weed infestation. The upper crust formed in plots was broken at the time of first weeding. In order to control attack of stem borer of maize and shoot fly, spraying of chlorpyriphos 35 EC @ 1.5 ml/ litter of water was done twice during the crop grown.

Harvesting, shelling and winnowing

Harvesting was done manually. The physiological maturity of all the treatments was judged visually before the crop was harvested. The harvesting was done on the basis of variety character. In order to eliminate the border effects, one outer row and 50cm at both the ends were removed first from each plots keeping net plot 4.0 m X 2.4 m. Five randomly selected sampled plants were removed first for post-harvest studies. Before harvesting the crop, cobs are picked manually and produce was left on threshing floor for sun drying separately by using luggage label for demarcation of plot wise produce. The remaining crop plants of each plot were harvested manually with the help of sickles and left for sun drying on field. The harvested plants (Stover) of each plot tied in bundles and weight of stover was recorded plot wise by using spring balance.

The shelling was done by labour with the help of manual maize sheller. Before the shelling, plot wise, weight of total cobs was recorded. Care was taken to avoid loss of grain during the operation of shelling and winnowing. Winnowing was done by supas. The weight of cleaned grains from each net plot was recorded in kilogrammes and then converted into quintal/hectare.

Experimental studies

The five competitive sample plants were randomly selected in each plot and tagged for recording the observations on grain yield and yield-attributing characters as detailed below:

A. Pre-harvest observation

Plant population

The plant population/m row length was recorded at 15 DAS and at maturity in rows randomly marked in each net plot. Then, the mean number of plants/m row length was worked out and converted into plant population /m^2

Plant height

The height of the plants from five randomly selected plants from net plot were measured in centimeters from the ground level to the base of well developed upper most leaf with the help of meter scale, after tassels

emergence stage, height was measured from base of plants to the base of tassel. The observations were recorded at 30, 60, 90 DAS and at maturity. Finally, mean was computed for each observation.

Number of leaves per plant

The no of leaves per plant was counted from the same randomly marked plant of each net plot at 30, 60, and 90 DAS growth stages and finally, mean was worked out for each observation.

Leaf area

The leaf area (LA) was recorded manually by measuring the length and maximum width of the leaf and multiplying it with a constant from five randomly selected leaves of marked plants at 30, 60 and 90 DAS growth stages and then it is multiplied by number of leaves per plant

$$LA = L \times W \times A \times N$$

Where**,**

LA= Leaf area

L= Length of leaf

W= Maximum width of the leaves

A= Constant (0.71)

N= Number of leaves per plant

Dry matter (g)

Dry weight at 30, 60, 90 DAS and at maturity and allowed to sundry then dry in an oven till constant weight is achieved. After this their weight was recorded on electronic balance. Later mean was worked out and presented as mean dry weight/plant in gram.

Chlorophyll content (SPAD)

It was measured with the help of an instrument named “SPAD-502” three leaves (from top, middle, and bottom) per plant were selected. Each leaf was punched for few seconds and values were recorded. There were 3 values per

plant and 15 value par plot (with 5 tagged sample plant per plot). The unit of chlorophyll content is SPAD.

B. Post-harvest observation

Post harvest observations are recorded for different characters are as given below:

Cobs per plant

The number of cobs per plant was counted from 5 already tagged plants and mean per plant was calculated for analysis. The observations were taken from all the plots.

Length of cobs

The length of five cobs obtained from five randomly selected plants was measured from the base of cobs to its tip with help of plastic scale. Than mean length of cobs were determined.

Girth of cobs

The thickness of the cobs of five tagged plant was measured at middle of the cob with the help of digital vernier calipers. After this the mean girth was worked out.

Grain rows per cob

The grain rows were counted from five cobs of each plot. Finally, treatment wise the mean number of grain rows per cob was determined.

Grain per rows

The grain separated from random five rows of five marked cobs of each plot and then number of grains was counted in each row. Finally, treatment wise the mean number of grains per rows was worked out.

Grain per cobs

The grain separated from each tagged cob from each plot was counted and then the mean numbers of grains per cob were worked out.

Seed index

Random seed sample were taken from the produce of each plot and then 100 seeds were counted manually and finally, their weight was taken accurately with the help of electronic balance.

Shelling percentage

It is the ratio of grain weight and whole cob expressed in percentage. It was worked out for each plot by using the following formula.

$$\text{Shelling percentage} = \frac{\text{Grain weight per cob}}{\text{Weight of whole cob}} \times 100$$

Grain yield (q/ha)

The seed yield of each plot was recorded after shelling the cobs the weight of seeds obtained from five plants used for post harvest studies in each plot was also added to the weight of grains of respective plots. After this, seed yield/plot was converted into seed yield per hectare by multiplying the conversion factor.

Stover yield (q/ha)

Stover yield obtain from the total of bundle weight, husk weight and the head remaining after selling of maize of respective plots. After this converted into per hectare by multiplying with same conversion factor as used in case of grain yield

Harvest index

It is refers to the ratio of economic yield (grain yield) in the (grain + stover) biological yields and it is expressed under a particular treatment in percentage. Harvest index was calculated for each plot by the following formula

$$\text{Harvest index} = \frac{\text{Economical yield}}{\text{Biological yield}} \times 100$$

C. Growth analytical observation

Leaf area index (LAI)

Leaf area index is expressed the ratio of leaf surface (one side only) to the ground area occupied by the crop. At 30 DAS three leaves each from 3 plants were randomly taken under each treatment mostly from the upper, middle portion of the plants. The length and maximum width of the leaf measured and it is multiplied by the constant Later it was multiplied by number of leaves per plant and thereafter means leaf area per plant was determined. Similar procedure was followed for getting the mean leaf area per plant at 60, 90 DAS. Leaf area index was determined by using Gardener's formula (1985).

$$LAI = \frac{(LA_1+LA_2)/2}{P}$$

Where,

LA_1 and LA_2= mean leaf area per plant at two successive stages

P= ground area/plant

Crop growth rate (CGR) (g cm^{-2} day^{-1})

The average daily increment in plant stand is an important characteristic. The crop growth rate was calculated as in increase in dry production per unit ground area per unit time. In this investigation the crop growth rate was worked out with the help of following formula given by Potter and James, (1972).

$$CGR = \frac{W_2 - W_1}{p\,(t_2 - t_1)}$$

Where,

p = ground area (cm^2)

W_1 -W_2 = difference in oven dry weight per unit area at time intervals

t_2 - t_1 = time interval in days

Relative growth rate (RGR) (g $g^{-1}day^{-1}$)

The Relative growth rate expresses the dry weight increase in time interval in relation to initial weight. In practical situations, the mean relative growth rate is calculated from measurements at t_1 and t_2 (Beadle, 1985).

$$RGR = \frac{Ln\ W_2 - Ln\ W_1}{(t_2 - t_1)}$$

Where,

W_1 = dry weight per unit area at t_1,

W_2 = dry weight per unit area at t_2,

$t_2 - t_1$ = time interval in days

Net assimilation rate (NAR) (g cm^{-2} day^{-1})

It is increased in dry weight of plant per unit leaf are per unit time. The net assimilation rate was calculated from the following equation: (Gregory, 1926)

$$NAR = \frac{(W_2 - W_1)}{(t_2 - t_1)} \times \frac{(Ln\ LA_2 - Ln\ LA_1)}{(LA_2 - LA_1)}$$

Where,

Ln = Natural log

LA_1= Leaf area of first sampling,

LA_2 = Leaf area of second sampling,

W_1= Dry weight per unit area at t_1,

W_2 = Dry weight per unit area at t_2,

$t_2 - t_1$ = time interval in days

Chemical analysis

Nutrient content in soil sample

For the estimation of soil pH, EC, organic carbon, nitrogen, phosphorus, potassium representative sample of soil were taken after

harvesting of crop. Soil samples were collected randomly from 0-30 cm depth with the help of soil auger from the field. These soil samples were then thoroughly mixed to get the composite sample. Requisite quantity of the soil from the composite sample was drawn and subjected to analysis for physico-chemical properties of the soil as per standard methods given below:

Soil pH

Soil pH was determined by glass electrode method in 1:2 soil water suspensions (Piper 1950).

Electrical conductivity (dSm^{-1})

Electrical conductivity was measured in the supernatant liquid of 1:2 soil: water suspensions by using solu-bridge method (Piper1950).

Organic carbon

Organic carbon content was determined by rapid titration method of Walkley and Black as described by Jackson (1965).

Nitrogen

The nitrogen supplying ability of the soil was determined by distilling soil with alkaline potassium permanganate solution. During the distillation easily utilizable and amino- N hydrolyzed nitrogen liberated as ammonia is measured. This serves as an index of nitrogen status of soil. Alkaline potassium permanganate method (Subhaiah and Asija, 1956) was followed to estimate available N of soil samples.

Phosphorus

Phosphorus was estimated by the Olsen's method. P is extracted from soil by $NaHCO_3$. P in the soil extract is determined calorimetrically using a photo electric colorimeter after developing blue colour, the intensity of which varies with the P concentration. The orthophosphate ion present in an acid molybdate solution, forms phospho- molybdate complex which is reduced by acid to produce blue colour, (Olsen *et.al.* 1954).

Potassium

The available potassium in soil sample can be determine by flame photometric method (Chapman and Pratt, 1961).The ammonium acetate use

as an extract which extracts the K which atomized into blue flame of flame photometer so that it gets excited on gaining energy and emits radiation of certain wave length in proportion to the concentration of K. the light energy is converted into electrical energy which is measured by a galvanometer.

Nutrient content in plant sample

For estimation of nitrogen, phosphorous, potassium representative sample of grain and straw were taken at the time of threshing. Each dried straw sample was ground to fine powder with the help of mortar and pistal for estimating the nutrient content. For estimating the nutrient content in grain, each sample was ground in an electrical grinder. Nutrient content in grain and straw determined using standard method given below:

Nitrogen

Nitrogen in plant sample was determinate by KELPLUS nitrogen estimation system. This is based on the Kjeldahl chemistry which consists of digestion, distillation and titration process.

Estimation of phosphorous and potassium

For the preparation of stock solution the plant and grain sample was digested in di-acid mixture of HNO_3 and $HClO_4$ (2:1) on hot plate till the clear solution was obtained and making its volume up to 100ml by distilled water.

Phosphorus

Phosphorus was estimated by vanado- molybdo phosphoric acid yellow colour method. The intensity of yellow colour was measured in spectrophotometer. This method is described by Koeing and Johnson, (1942).

Potassium

The determination is based on measurement of spectral line intensities of potassium atoms excited when passing through a flame. The wave lengths of spectral line are proportional to the concentration of atoms of that element (Black 1965).

Nutrient uptake

The uptake of nitrogen, phosphorus and potassium at harvest in grain and straw was estimated by using the following formula:

$$\text{Nutrient uptake (kg ha}^{-1}) = \frac{\text{Nutrient content (\%) in grain/straw} \times \text{grain/straw yield (kg ha}^{-1})}{100}$$

Estimation of protein and nitrogen in seed

The nitrogen content was estimated by micro kjeldhal method (A.O.A.C., 1965) as given under by (Gopalan *et a*l., 1985): 0.1 gm of sample was digested with concentrated sulphuric acid (10 ml) in 9 digestion of ($CuSO_4$, $5H_2O$ and 0.34 g solution selenate). After digestion for about 3 hours till liquid becomes colourless, the digestion tube was allowed to cool and the contents carefully diluted to 100 ml with distilled water. The solution is then transferred quantitatively to a distillation apparatus, 15 ml of 40% of sodium hydroxide was added and the liberating ammonia was collected in a flask containing 10 ml of 2 percent boric acid with two drops of mixed indicator (Bromocrysol green + methyl red). Distillation was continued for 5 minute appearance of green colour to ensure the complete evaluation of ammonia. After distillation solution was titrated with 0.1N H_2SO_4.

Nitrogen and protein percent was calculated by the following formula:

$$\text{Nitrogen} = \frac{14 \text{ x Normality of } H_2SO_4 \text{ x Vol. of } H_2SO_4 \text{ x } 100}{\text{weight of sample x } 100}$$

Protein percent in the sample was estimated multiplying nitrogen percent of sample by factor 6.25.

Protein (%) = Nitrogen % x 6.25

Economics of the treatments

The cost of cultivation, gross and net monetary returns (Rs/ha) and B-C ratio for various treatments were calculated at prevailing market rates.

Economics (net return/ha) from all the treatments were worked out by deducting the total expenditure incurred under each treatment from the total gross income obtained by the produce (grain+stover) of the respective treatments. The costs of labour, seed, fertilizer, field preparation as well as return from the produce were calculated at prevailing market rates of the

inputs. Cost of cultivation was calculated by adding cost of items used in cultivation (Rs/ha) while total expenditure was calculated by adding cost of cultivation with the treatment cost (Rs/ha).

Gross monetary returns (Rs/ha)

The value realized from the produce obtained under each treatment was computed on the basis of existing market price of the produce (both grain and stover) as the gross monetary returns (GMR), per hectare under different treatments.

Gross monetary returns (Rs) = value of grain + value of stover

Net monetary returns (Rs/ha)

The net monetary returns (NMR) per hectare under each treatment were determined by subtracting the cost of cultivation of a particular treatment from the GMR of the treatment

Net monetary returns (Rs.) = Gross monetary return – Total cost of cultivation

Benefit – cost ratio

Benefit-cost ratio is the index indicating monetary gains over each rupee investment under different treatments. It is also termed as profitability and it is calculated by using the following formula:

$$\text{Benefit cost ratio} = \frac{\text{GMR (Rs/ha/year)}}{\text{Cost of cultivation (Rs/ha/year)}}$$

Statistical analysis

Data recorded on various observations were tabulated and subjected to their statistical analysis by using techniques of the analysis of variance by Panse and Sukhatme (1967). The significance of the treatments was tested by using ‘F’ test and when ‘F’ test shown the significance, the difference between the treatments was further tested with critical difference (C.D.) at 5% level of significance. The skeleton of analysis of variance in given as below:

Table 5. The skeleton of analysis of variance

Source of variation	Degree of freedom (d.f.)	Sum of square (S.S.)	Mean sum of square (M.S.S.)	F value calculated	F value at 5%
Replications	2				
Treatments	6				
Error	12				
Total	20				

$$SEm \pm = \sqrt{\frac{EMS}{r}}$$

$$SEd \pm = SEm \times \sqrt{2}$$

$$CD = SEd \times t_{(0.05)} \text{ at error degree of freedom}$$

Where,

SEm± = standard error of treatments

SEd± = standard error of difference between treatment means

CD = Critical difference

r = number of replications

RESULTS

Endeavour have been made here under the ensuring chapter to present the results of experiments carried out during the kharif 2014 on hybrid maize, with a view to elicit the relative performance of newly developed maize hybrids under rainfed condition. The observations pertaining to morphological, growth analytical and yield attributing characters along with the yield of maize have been processed statistically to assess the degree of variance due to various treatments.

The analysis of variance have been appended at the end of this thesis after the bibliography and referred at appropriate places in the text during the course of interpretation.

The effects of experimental variables have been described in the order in which they occupy the positions in the analysis of variance. In mean values, treatments, data as statistically significant are discussed at length in order to provide a quick grasp of trends in responses exhibited by certain parameters reported.

Pre harvest observations

Plant population

The data pertaining to plant population were first recorded per meter row length at 15 DAS and at harvest under different treatments and it converted into m^2, then statistically analyzed as shown in Appendix I. The data so obtained were presented in Table 6, and depicted in Figure 3.

It indicates that the plant population of maize in different hybrids was same in all plants. It ranged from 6.57 to 6.63 at 15 DAS and 6.40 to 6.53 at harvest.

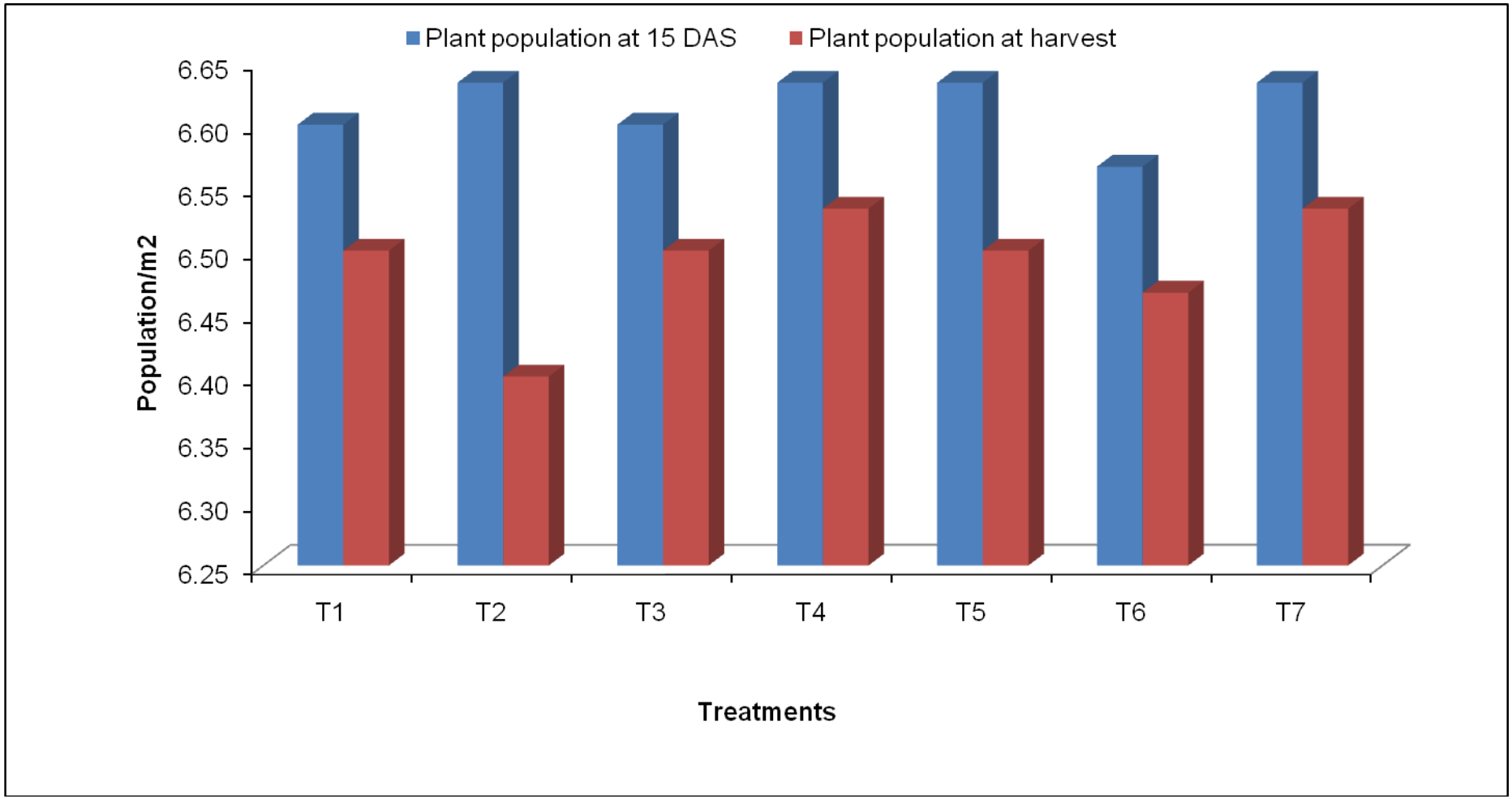


Fig.3: Plant population per m^2 of different maize hybrids at 15 DAS and maturity

Table 6. Plant population per m^2 of different maize hybrids at 15 DAS and maturity

Notation	Treatments	15 DAS	At Maturity
T_1	JKMH 502	6.63	6.40
T_2	JKMH 1701	6.60	6.50
T_3	JKMH 4545	6.63	6.53
T_4	JKMH 4023	6.63	6.53
T_5	JKMH 4025	6.63	6.50
T_6	JKMH 4029	6.57	6.47
T_7	JK SURABHI	6.60	6.50
	SEm±	**0.40**	**0.50**
	CD(P=0.05)	**NS**	**NS**

Plant height (cm)

The plant height recorded at 30, 60, 90 DAS and maturity stages were statistically computed (Appendix I). The mean values so obtained are presented in Table 7 and exhibited through Figure 4.

Table 7. Plant height (cm) of maize hybrids at different growth intervals

Notation	Treatment	30 DAS	60 DAS	90 DAS	At Maturity
T_1	JKMH 502	15.76	154.51	166.32	165.21
T_2	JKMH 1701	12.89	168.42	180.06	179.02
T_3	JKMH 4545	11.80	122.24	137.80	135.20
T_4	JKMH 4023	12.65	139.92	152.77	150.60
T_5	JKMH 4025	13.01	148.82	160.02	159.00
T_6	JKMH 4029	12.09	133.60	146.80	145.22
T_7	JK SURABHI	15.23	156.30	172.82	171.60
	SEm±	**0.62**	**0.63**	**0.60**	**0.48**
	CD(P=0.05)	**1.90**	**1.95**	**1.83**	**1.49**

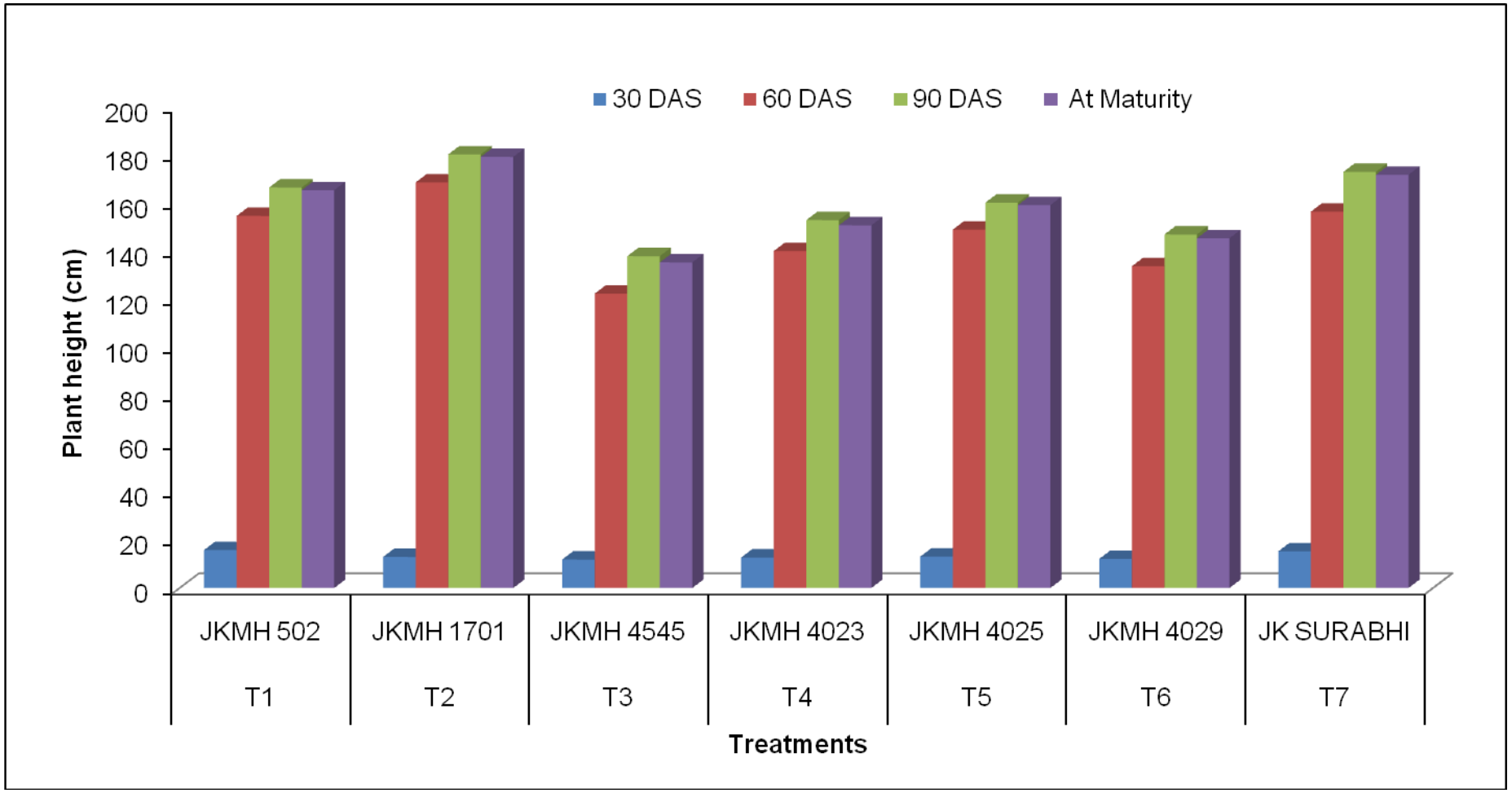


Fig.4: Plant height (cm) of maize hybrids at different growth intervals

The plant height in general, increased with the age of plant growth up to 90 days of observation. The increase in height was very fast between 30 to 60 days stage of growth there after the increase was slow down between 90 to harvest stage the growth of the plant is negligible in some hybrids.

There is a significant difference recorded among the different hybrids with respect to plant height at every growth stages. At 30 DAS, JKMH 502 was found tallest (15.76 cm) which is at par with JK Surabhi (15.23) as compared to other hybrids JKMH 1701 (12.89), JKMH 4023 (12.65), JKMH 4029 (12.09), JKMH 4025 (13.01), JKMH 4545 (11.80) which were found at par. At 60 DAS JKMH 1701 attained the maximum plant height up to 168.42 cm being significantly superior to that of all the remaining hybrids. The lowest height (122.24 cm) was observed in case of JKMH 4545. The other hybrids show intermediate position being statistically identical to each other in this character.

At 90 DAS the hybrid JKMH 1701 become significantly tallest one measuring up to 180.06 cm as compare to all rest of hybrids on other hand the almost lowest height 137.80 cm was recorded in hybrid JKMH 4545. The remaining hybrids attained the intermediate position where the difference in their height is significant.

Leaves per plant

The number of leaves per plant was obtained at 30, 60 and 90 DAS. The mean number of leaves presented in Table 7. It is evident that the number of leaves increases with increase in advancement of growth stages.

The number of leaves at 30 and 60 DAS has been found to be non significant. At 90 DAS the hybrid JK Surabhi attained the highest number of leaves (13.66). The lowest number of leaves was found in JKMH 1701 (10.33). The hybrids JKMH 4029 (12), JKMH 4025 (12), JKMH 4023 (11.66), JKMH 4545 (11) are at par.

Table 8. Leaves per plant at different growth stages

Notation	Treatment	30 DAS	60 DAS	90 DAS
T_1	JKMH 502	10.00	11.00	11.66
T_2	JKMH 1701	10.00	10.33	10.33
T_3	JKMH 4545	9.00	10.66	11.00
T_4	JKMH 4023	10.33	10.33	11.66
T_5	JKMH 4025	10.00	10.66	12.00
T_6	JKMH 4029	10.33	11.00	12.00
T_7	JK Surabhi	10.33	12.33	13.66
	SEm±	**0.54**	**0.61**	**0.22**
	CD(P=0.05)	**NS**	**NS**	**0.66**

Leaf area

The leaf area per plant was obtained at 30, 60, and 90 DAS the data were computed statistically as indicated in Appendix I. The mean leaf area presented in Table 9. It is evident from data that the leaf area per plant orderly increased with the advancement in growth stages.

Table 9. Leaf area (cm²) of maize hybrids at different growth stages

Notation	Treatment	30 DAS	60 DAS	90 DAS
T_1	JKMH 502	749.97	3049.72	3648.04
T_2	JKMH 1701	627.21	2881.13	3223.05
T_3	JKMH 4545	529.47	2930.48	3372.90
T_4	JKMH 4023	901.30	2940.17	3729.58
T_5	JKMH 4025	967.65	3069.36	3994.43
T_6	JKMH 4029	1050.55	3228.73	4036.35
T_7	JK Surabhi	1119.79	3774.58	4769.18
	SEm±	**123.39**	**13.11**	**6.80**
	CD(P=0.05)	**380.40**	**40.43**	**20.95**

At 30 DAS maximum leaf area was recorded in JK Surabhi (111.79 cm²) closely followed by JKMH 4029 (1050.55 cm²), JKMH 4025 (967.65 cm²), JKMH 4023 (901.30 cm²) and the difference between them is not significant. The lowest leaf area was recorded at 30 DAS was in JKMH 4545 (529.47 cm²). At 60 DAS the highest leaf area was observed in JK Surabhi (3774.58 cm²) and the lowest leaf area was in JKMH 1701 (2881.13 cm²). At 90 DAS

the maximum leaf area was recorded in JK Surabhi (4769.18 cm^2) which is significantly superior to other hybrids. The lowest leaf area was observed in JKMH 1701 (3223.05).

Dry weight per plant

The dry weight per plant was obtained at 30, 60, 90 DAS and at harvest stage the data were computed statistically as indicated in Appendix I. The mean dry weight presented in Table 10 and illustrated diagrammatically in Figure 5. It is evident from data that the dry matter accumulation per plant orderly increased with the advancement in growth stages till to maturity of crop under all treatments. But the rate of increment in dry matter production per plant was most rapid between 60-90 DAS to maturity period.

Table 10. Dry weight per plant (g) of maize hybrids at different growth stages

Notation	Treatment	30 DAS	60 DAS	90 DAS	At Maturity
T_1	JKMH 502	6.1	21.38	72.53	86.34
T_2	JKMH 1701	6.34	21.4	76.45	92.72
T_3	JKMH 4545	5.66	20.75	64.94	76.42
T_4	JKMH 4023	6.67	22.82	84.64	98.32
T_5	JKMH 4025	6.75	24.86	87.76	102.82
T_6	JKMH 4029	7.11	25.12	94.32	108.54
T_7	JK Surabhi	7.29	27.8	116.85	132.78
	SEm±	**1.22**	**0.51**	**0.63**	**1.72**
	CD(P=0.05)	**NS**	**1.58**	**1.97**	**5.31**

The hybrid JK Surabhi recorded significantly higher dry weight per plant at 60 DAS (27.8). At 60 DAS the hybrids JKMH 4029, JKMH 4025, JKMH 1701, JKMH 502, JKMH 4545 has been found at par. At 90 DAS and at maturity the hybrid JK Surabhi has recorded the significantly higher dry weight 116.85 g and 132.78 respectively. The lower dry weight has been recorded in JKMH 4545 at 90 DAS and at maturity i.e., 64.94 g and 76.42 g.

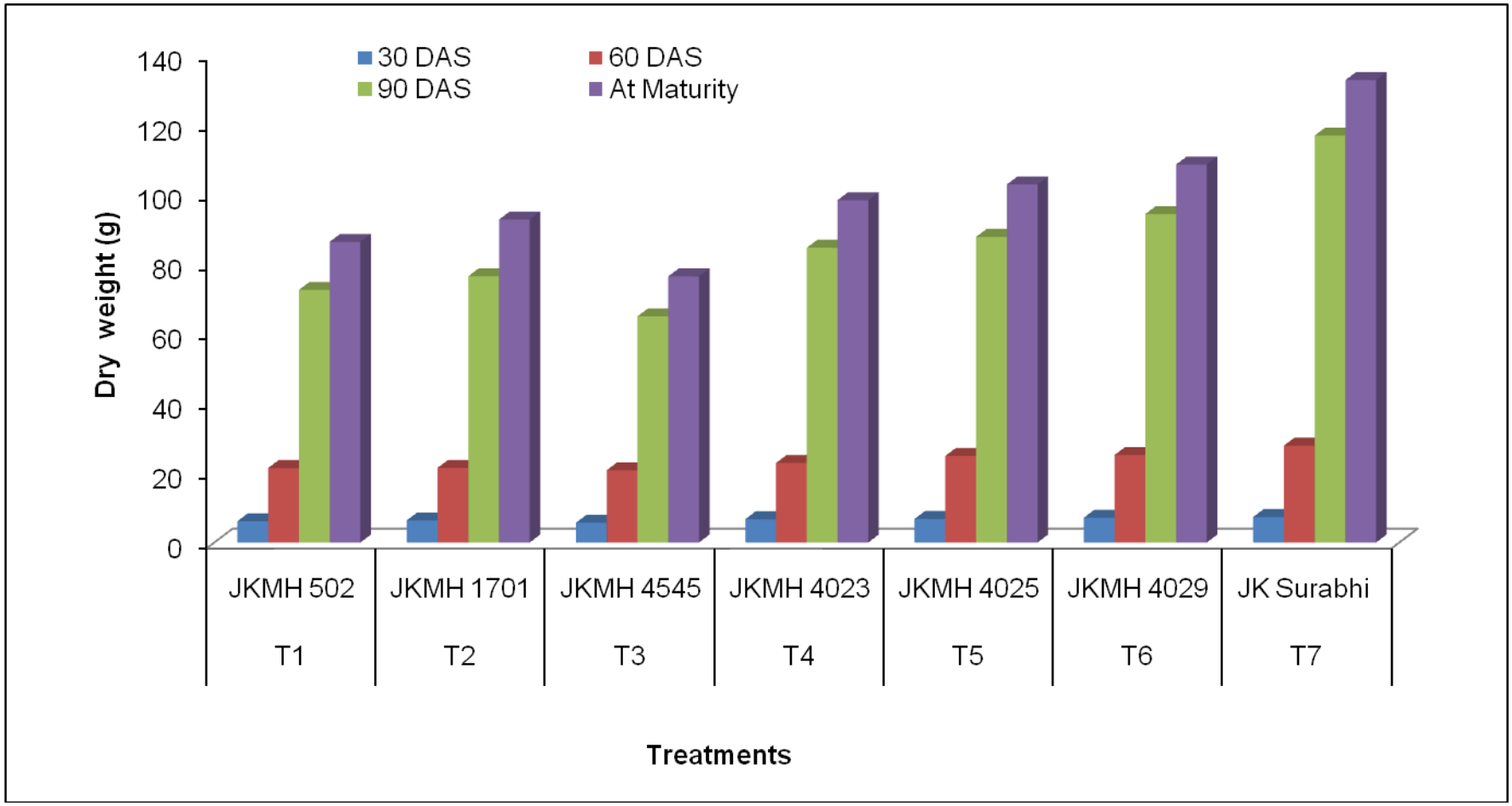


Fig.5: Dry weight per plant (g) of maize hybrids at different growth stages

Chlorophyll index

The chlorophyll index was measured in each treatment was statistically computed (appendix I) and the data are presented in Table 11, and diagrammatically illustrated in Figure 6. The SPAD value was varied with the age of the plant. It is gradually increases up to flowering and grain development and then decrease. So because of its variability we took average to theses 3 intervals. The means value so obtained were found maximum in JK Surabhi (28.91) which was significantly superior to all other hybrids. The lower chlorophyll index was observed in hybrid JKMH 4023 (21.12).

Table 11. SPAD value of maize hybrids at different growth intervals

Notation	Treatment	30 DAS	60 DAS	90 DAS	MEAN
T_1	JKMH 502	32.76	20.65	31.02	28.14
T_2	JKMH 1701	32.44	24.16	26.73	27.77
T_3	JKMH 4545	22.05	30.78	27.34	26.72
T_4	JKMH 4023	26.08	16.21	21.08	21.12
T_5	JKMH 4025	27.17	24.35	27.64	26.38
T_6	JKMH 4029	22.94	31.34	20.63	24.97
T_7	JK Surabhi	30.74	32.56	23.43	28.91
	SEm±	**1.79**	**2.54**	**0.97**	**0.88**
	CD(P=0.05)	**5.51**	**7.84**	**2.99**	**2.70**

Leaf area index

The leaf area index measured in each treatment was statistically computed in Appendix I. The mean data so obtained were presented in Table 12 and diagrammatically illustrated in Figure 7. The LAI at 60 and 90 DAS has been found to be non significant.

Net assimilation rate (NAR)

Data pertaining to NAR ($g/cm^2/day$) at successive growth stages as affected by different treatments are given in Table 12 and Figure 8. Result showed that the NAR at 30-60 DAS has been found non significant. At 60-90 days stage the hybrid JK Surabhi having the maximum NAR (6.93 $g/m^2/day$) and the lowest NAR were found in case of JKMH 4545 (4.66 $g/cm^2/day$).

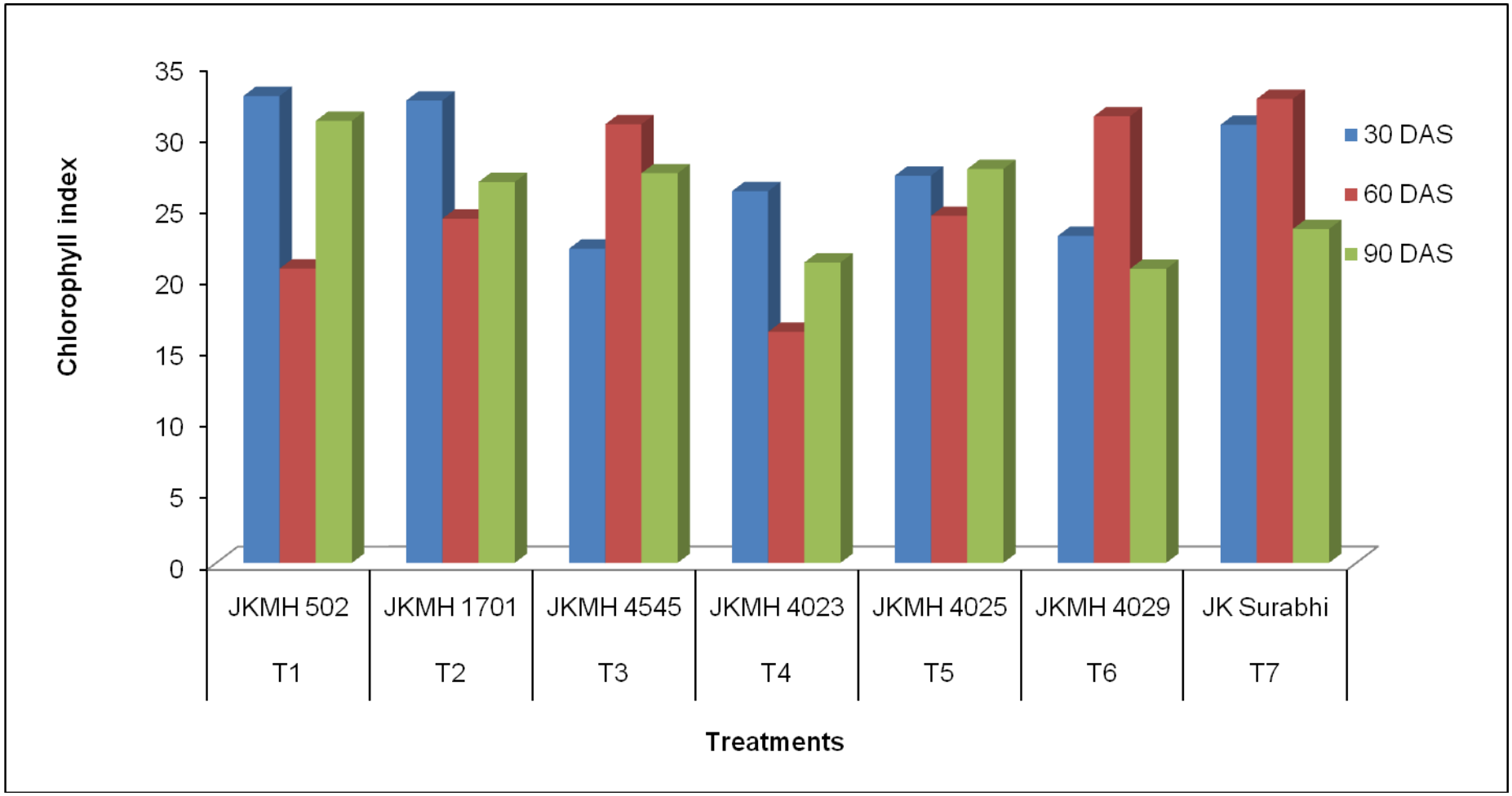


Fig.6: SPAD value of maize hybrids at successive growth interval

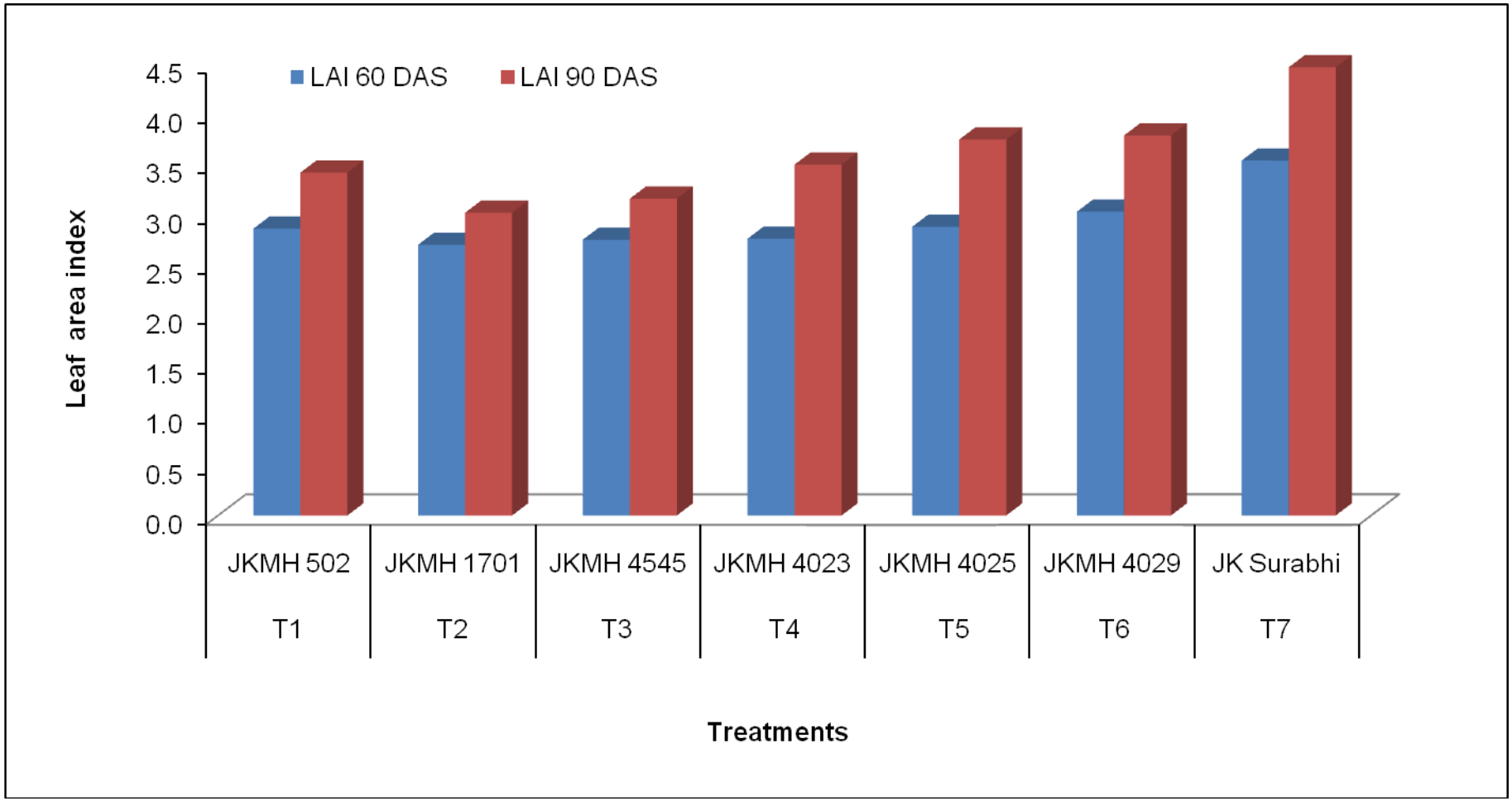


Fig.7: Leaf area index of maize hybrids at successive growth interval

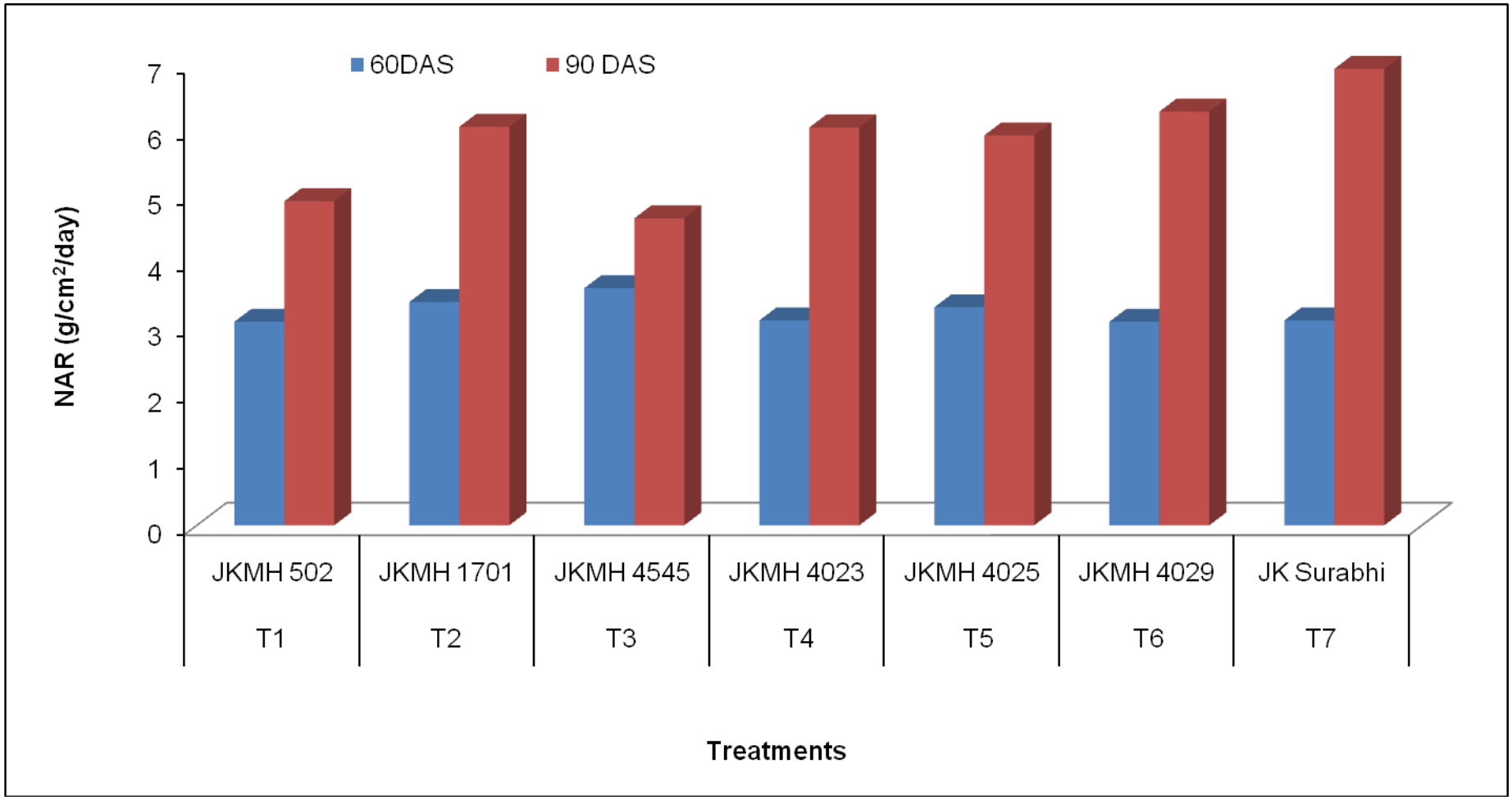


Fig.8: Net assimilation rate (g/cm^2/day) of maize hybrids at successive growth interval

Table 12. Leaf area index, Net assimilation rate (g/cm^2/day) at successive growth interval

Notation	Treatment	LAI		NAR (g/cm^2/day)	
		60 DAS	90 DAS	60DAS	90 DAS
T_1	JKMH 502	2.86	3.42	3.09	4.92
T_2	JKMH 1701	2.70	3.02	3.39	6.05
T_3	JKMH 4545	2.75	3.16	3.60	4.66
T_4	JKMH 4023	2.76	3.50	3.11	6.04
T_5	JKMH 4025	2.88	3.75	3.31	5.92
T_6	JKMH 4029	3.03	3.79	3.09	6.28
T_7	JK Surabhi	3.54	4.47	3.11	6.93
	SEm±	**0.86**	**0.40**	**1.08**	**0.43**
	CD(P=0.05)	**NS**	**NS**	**NS**	**1.34**

Crop growth rate (CGR)

Data pertaining to CGR (g/cm^2/day) as affected by different treatments are given in Table 13 and Figure 9. Result revealed that at 60 DAS the CGR has been found to be non significant. JK Surabhi (19.59 g/cm^2/day) shows maximum CGR at 90 DAS. At 90 DAS the lowest CGR was recorded in JKMH 4545 (9.32 g/cm^2/day). The hybrids JKMH 4025 (13.90 g/cm^2/day), JKMH 4023 (13.66 g/cm^2/day) and JKMH 1701 (12.11 g/cm^2/day), JKMH 502 (11.30 g/cm^2/day) are at par. At harvest stage the hybrid JKMH 1701 gave the maximum CGR (10.73 g/cm^2/day) which is at par with the hybrid JK Surabhi (10.51 g/cm^2/day) and lowest CGR at harvest has been recorded in JKMH 4545 (7.26 g/cm^2/day). The hybrids JKMH 4029 (9.34 g/cm^2/day), JKMH 502 (9.15 g/cm^2/day) and JKMH 4023 (9.07 g/cm^2/day) are at par.

Relative growth rate (RGR)

Data pertaining to RGR (g/g/day) at successive growth stages as affected by different treatments are given in Table 13 and Figure 10. Result indicated that the RGR has been found to be non significant at all the growth stages.

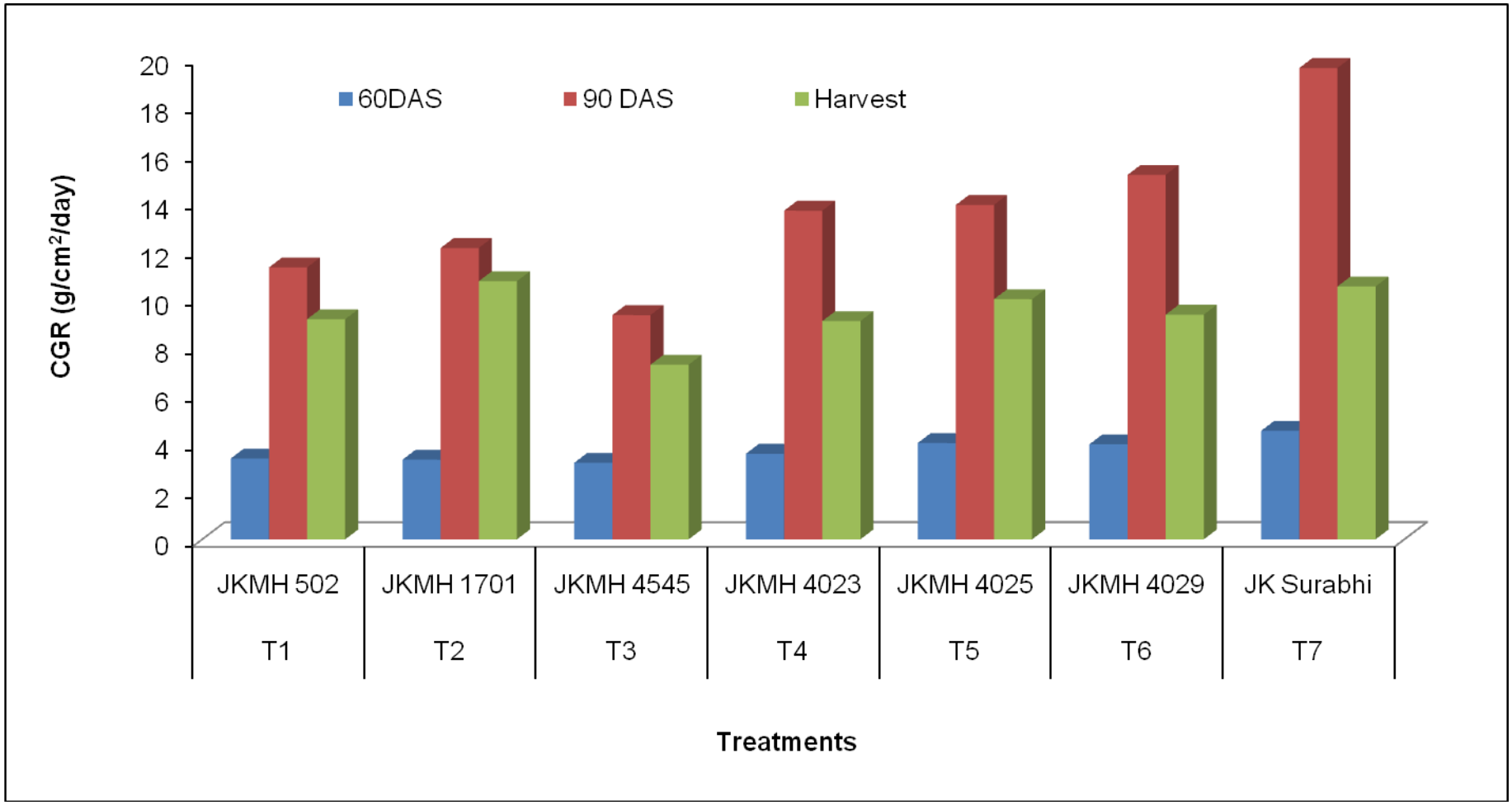


Fig.9: Crop growth rate (g/cm^2/day) of maize hybrids at successive growth intervals

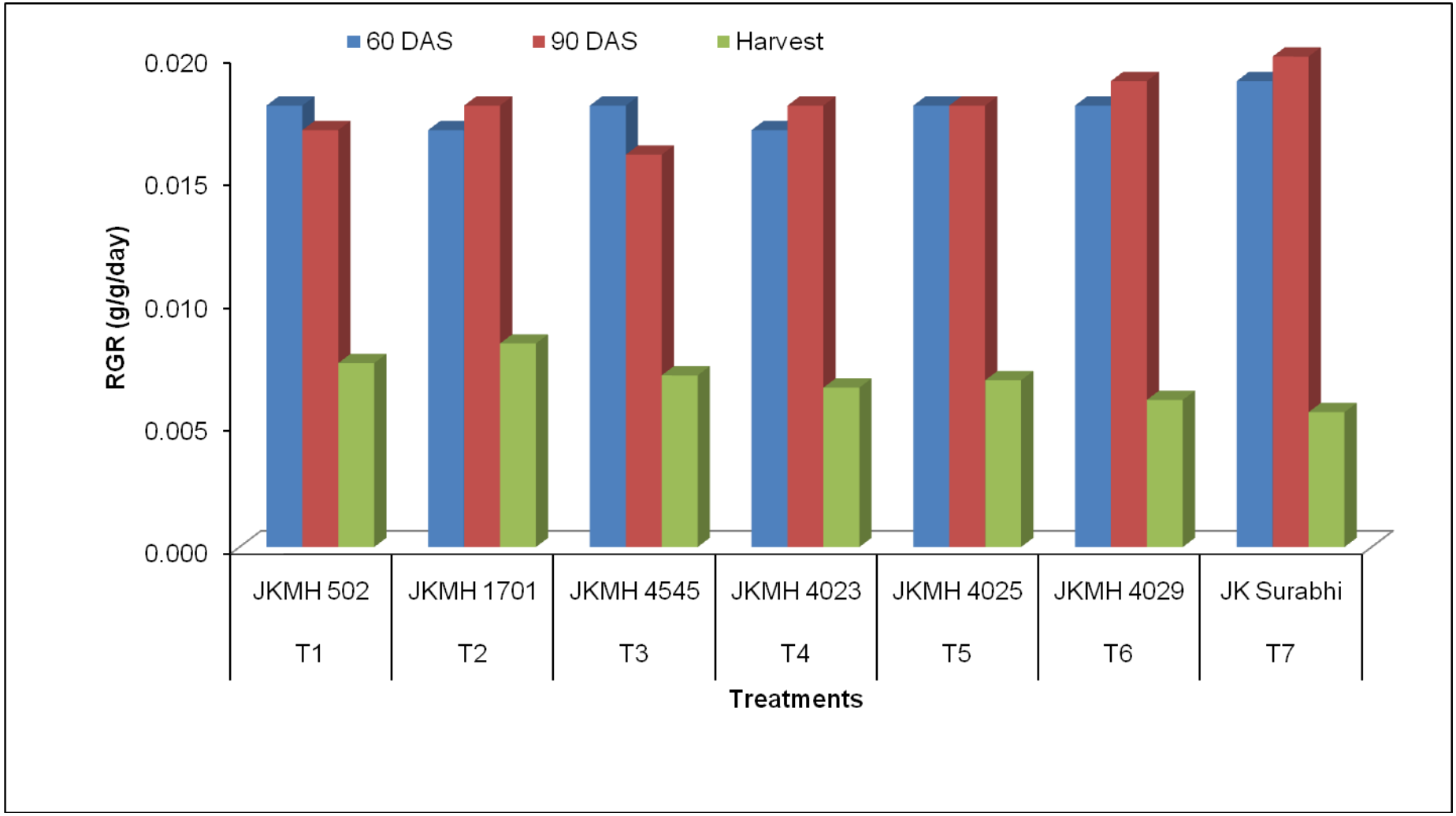


Fig.10: Relative growth rate (g/g/day) of maize hybrids at successive growth intervals

Table 13. Crop growth rate (g/cm^2/day) and relative crop growth rate (g/g/day) of maize hybrids at successive growth intervals

Notation	Treatment	CGR (g/cm^2/day)			RGR (g/g /day)		
		60DAS	90 DAS	Harvest	60 DAS	90 DAS	Harvest
T_1	JKMH 502	3.36	11.30	9.15	0.018	0.017	0.0075
T_2	JKMH 1701	3.31	12.11	10.73	0.017	0.018	0.0083
T_3	JKMH 4545	3.18	9.32	7.26	0.018	0.016	0.0070
T_4	JKMH 4023	3.56	13.66	9.07	0.017	0.018	0.0065
T_5	JKMH 4025	4.00	13.90	9.98	0.018	0.018	0.0068
T_6	JKMH 4029	3.95	15.15	9.34	0.018	0.019	0.0060
T_7	JK Surabhi	4.51	19.59	10.51	0.019	0.020	0.0055
	SEm±	**1.28**	**0.91**	**0.69**	**0.009**	**0.005**	**0.0028**
	CD(P=0.05)	**NS**	**2.83**	**2.10**	**NS**	**NS**	**NS**

Grain rows per cob

The number of grain rows was counted from each sample cob and average was worked out under each treatment. The data were statistically computed (Appendix II) then presented in Table 14 and depicted diagrammatically as Figure 11. This parameter being one of the major yield attributes were found to different maize hybrids. The hybrid JKMH 4029 recorded maximum number of grain rows per cobs up to 14, being significantly superior to all remaining hybrids. The hybrid which produces minimum number of grain rows per cob was JKMH 502 (10). The hybrid JKMH 1701, JK Surabhi, JKMH 4023, JKMH 4025, JKMH 4545 recorded equal grain rows i. e, 12 grain rows per cob.

Grains per row

The number of grain per row was observed treatment wise and the data so obtained were subjected to statistical analysis as revealed from Appendix II. The mean values are being presented in Table14, and diagrammatically exhibited in Figure 11. The maximum number of grains per row was found in hybrid JKMH 502 (27.00) followed by JKMH 4029 (24.49) which is at par with the hybrids JKMH 4023 (23.62), JK Surabhi (23.01), JKMH 4025 (23) and JKMH 1701 (22.60). The lowest grains per cob were recorded in JKMH 4545 (18.24).

Table 14. Grain row per cob, grain per rows, total grain per cob, of maize hybrids

Notation	Treatment	Grain rows/Cob	Grain/Row	Grains/Cob
T_1	JKMH 502	10.00	27.00	270.00
T_2	JKMH 1701	12.00	22.60	265.96
T_3	JKMH 4545	12.00	18.24	218.96
T_4	JKMH 4023	12.00	23.62	283.49
T_5	JKMH 4025	12.00	23.00	276.00
T_6	JKMH 4029	14.00	24.49	342.86
T_7	JK Surabhi	12.00	23.01	276.23
	SEm±	**0.14**	**0.55**	**0.30**
	CD(P=0.05)	**0.43**	**1.70**	**0.96**

Grains per cob

Data on grains per cob were statistically computed (Appendix II). The mean values so obtained are being presented in Table 14 and diagrammatically exhibited in Figure 11. The maize hybrid JKMH 4025 (322.08) having significantly maximum number of grains per cob. The lowest number of grains per cob was found in case of hybrid JKMH 4545 (218.96).

Length of cob

The length of cob was measured in each treatment and data were statistically computed (Appendix II). The mean data so obtained are presented in Table15 and diagrammatically illustrated in Figure 12. The length of cob found to deviate significantly in different hybrids. The hybrid JK Surabhi recorded the maximum cob length (16.23 cm) which is significantly higher than other hybrids. The lowest length of cob is found in case of hybrid JKMH 502 (12.11) closely followed by JKMH 4023 (12.77).

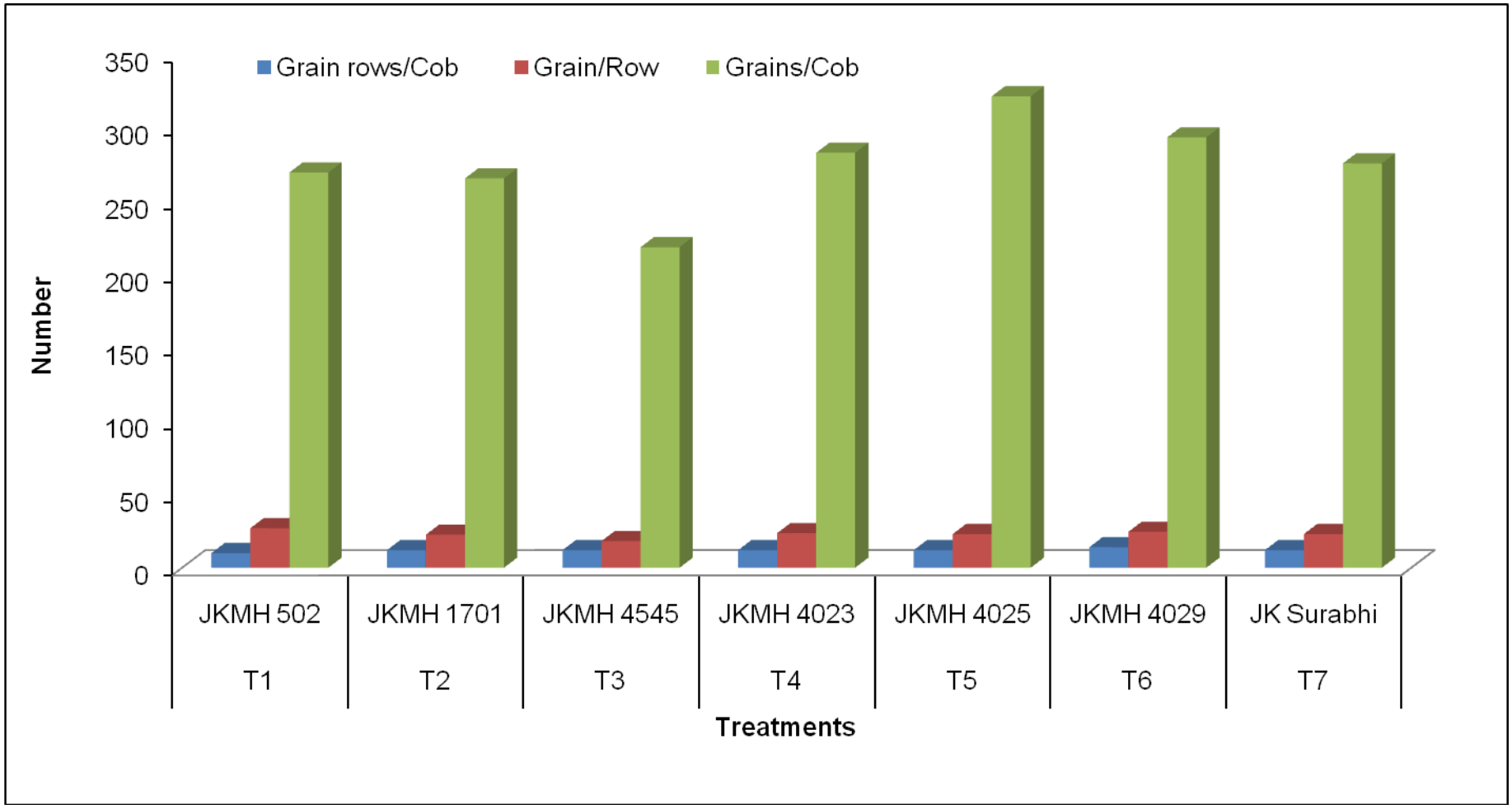


Fig.11: Grain row per cob, grain per rows, total grain per cob of maize hybrids

Girth of cobs

Data on cob girth were statistically computed (appendix II). The mean values so obtained are being presented in table 15 and diagrammatically illustrated in Figure 12. The final mean values are exhibited through figure.10. The highest cob girth was measured in case of hybrid JKMH 4545 (15.01 cm) which is at par with the hybrids JKMH 1701 (14.42), JK Surabhi (13.89), JKMH 4025 (13.59), JKMH 502 (13.4), JKMH 4029 (13.4), JKMH 4023 (13.05).

Grain weight per cob

The observation on cob weight was taken after removing the husk of each sample cob and average was worked out under each treatment. The data were statistically computed (Appendix II) and then presented in Table 15 and depicted diagrammatically as Figure 12. The Maximum cob weight is observed in case of hybrid JK Surabhi was 91.06 g which is significantly superior to all other hybrids the lowest grain weight of cob (65.68 g) was found in hybrid JKMH 4545.

Seed index

Data related to seed index as influenced by different treatments are given in Table15 and graphically illustrated through the Figure 12. Data revealed that the seed index was found maximum under hybrid JK Surabhi (33.33 g) which is statistically identical to hybrid JKMH 1701 (32.00 g) while minimum seed index (27.33 g) was recorded in hybrid JKMH 4025. The hybrids JKMH 4029 (30.67), JKMH 4023 (30.33), JKMH 502 (30) and JKMH 4545 (30) are at par.

Protein content

The observation on protein content was taken after removing the husk of each sample cob and average was worked out under each treatment. The data were statistically computed (Appendix II) and then presented in Table 15 and depicted diagrammatically as Figure 13. The Maximum protein content is observed in case of hybrid JK Surabhi was 9.12 % closely followed by JKMH 502 (9.10 %),JKMH 1701 (9.09 %), JKMH 4545 (9.06%), JKMH 4029 (9.02

%) and difference between them was non significant. The lowest protein content was obtained in JKMH 4023 (8.89 %).

Table 15. Cob length (cm), cob girth (cm) cob weight (g) and seed index (g) of different maize hybrids

Notation	Treatment	Cob length	Cob girth	Grain weight/Cob (g)	Seed index (g)	Protein content (%)
T_1	JKMH 502	12.11	13.40	81.00	30.00	9.10
T_2	JKMH 1701	14.46	14.42	85.10	32.00	9.09
T_3	JKMH 4545	13.33	15.01	65.68	30.00	9.06
T_4	JKMH 4023	12.77	13.05	85.98	30.33	8.89
T_5	JKMH 4025	15.45	13.59	88.02	27.33	8.95
T_6	JKMH 4029	14.21	13.4	90.16	30.67	9.02
T_7	JK Surabhi	16.23	13.89	91.06	33.33	9.12
	SEm±	**0.39**	**0.63**	**0.28**	**0.27**	**0.02**
	CD(P=0.05)	**1.21**	**1.94**	**0.86**	**0.82**	**0.06**

Grain yield

The data pertaining to grain yield as influenced by different treatments were statistically analyzed as shown in appendix II. These were presented in Table 16 and depicted in Figure 14. The evident from data that the grain yield (q/ha) significantly varied due to effect of hybrids. The grain yield of maize among the all hybrid was highest under JK Surabhi (59.84 q/ha) which was significantly superior to all other hybrids. The lowest grain yield was obtained by the hybrid JKMH 4545 (42.89 q/ha) which were significantly lower than all other hybrids. The hybrids JKMH 4023 (56.14) and JKMH 1701 (55.32) are found at par.

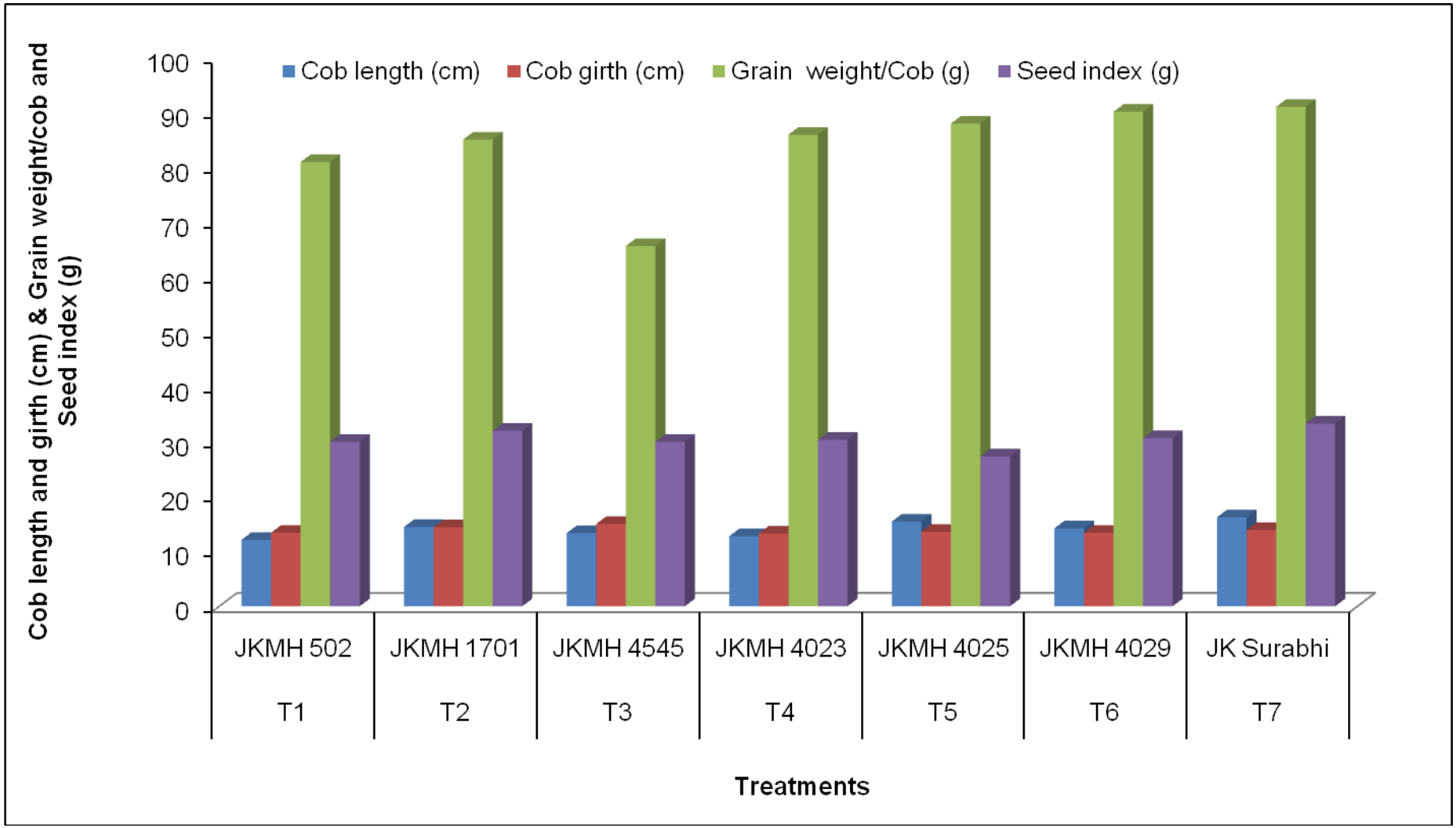


Fig.12: Cob length (cm), cob girth (cm) grain weight per cob (g) and seed index (g) of different maize hybrids

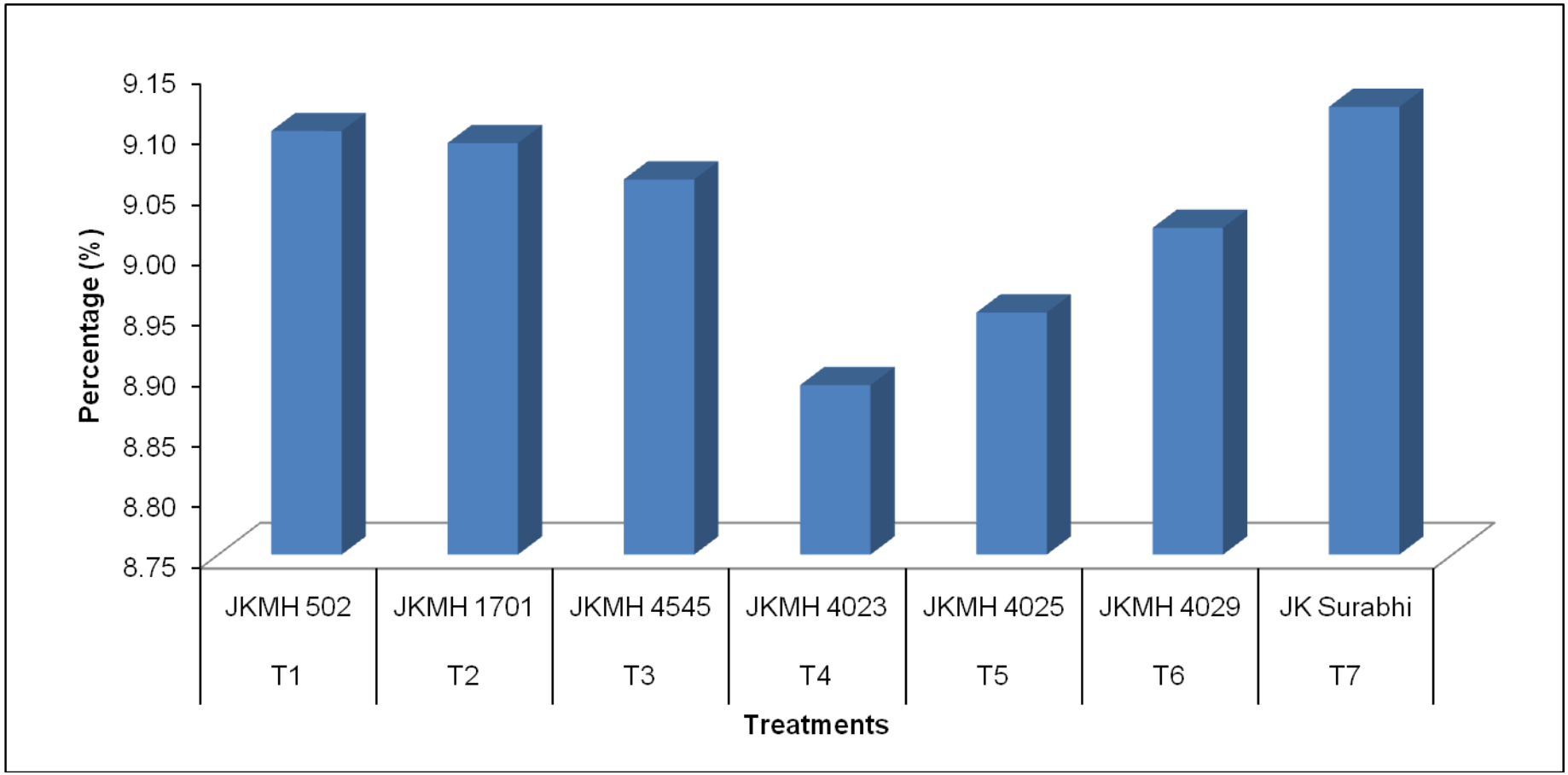


Fig.13: Protein content (%) of different maize hybrids

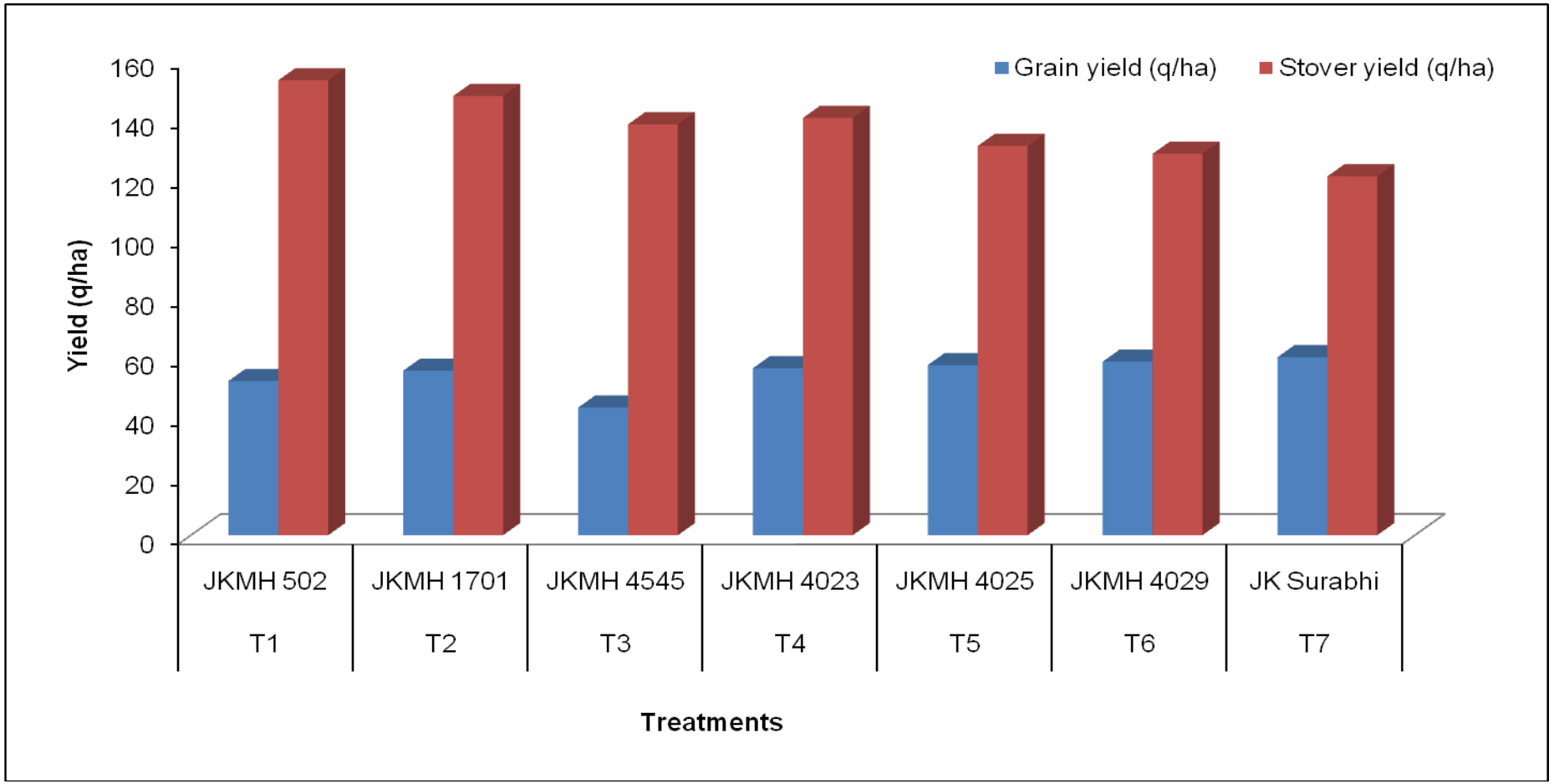


Fig.14: Grain yield (q/ha), stover yield (q/ha of different maize hybrids

Table 16. Grain yield (q/ha), stover yield (q/ha), shelling percentage and harvest index of different maize hybrids

Notation	Treatment	Grain yield	Stover yield	Shelling Percentage	Harvest index
T_1	JKMH 502	51.84	152.98	56.68	25.31
T_2	JKMH 1701	55.32	147.68	65.28	27.20
T_3	JKMH 4545	42.89	138.15	56.38	23.69
T_4	JKMH 4023	56.14	140.30	65.05	28.57
T_5	JKMH 4025	57.20	130.89	65.12	30.41
T_6	JKMH 4029	58.33	128.24	65.36	31.26
T_7	JK Surabhi	59.84	120.68	66.24	33.14
	SEm±	**0.29**	**0.50**	**0.04**	**0.33**
	CD(P=0.05)	**0.90**	**1.56**	**0.12**	**1.02**

Stover yield

Data on stover yield (q/ha) were statistically computed (appendix II). The mean values so obtained are being presented in Table 16, and graphically exhibited through Figure14. It is evident from data the stover yield of maize significantly varied due to different hybrids. The maximum stover yield were found in case of hybrid JKMH 502 (152.98 q/ha) which is significantly superior to all other hybrids the lowest stover yield (120.68 q/ha) was recorded in case of hybrid JK Surabhi.

Harvest index

The data pertaining to harvest index as influenced by different treatments were statistically analyzed as shown in Appendix II. These are presented in Table 16 and depicted through Figure 15. JK Surabhi recorded significantly maximum harvest index was 33.14. The lowest harvest index found in JKMH 4545 (23.69).

Shelling percentage

The data pertaining to shelling percent as influenced by different treatments were statistically analyzed as shown in Appendix II. These are presented in Table 16 and depicted through Figure 15. JK Surabhi recorded significantly maximum shelling percent was 66.24. The lowest harvest index found in JKMH 4545 (56.38). The hybrid JKMH 4029 (65.36), JKMH 1701 (65.28) and JKMH 4025 (65.12), JKMH 4023 (65.05) has been found to be at par.

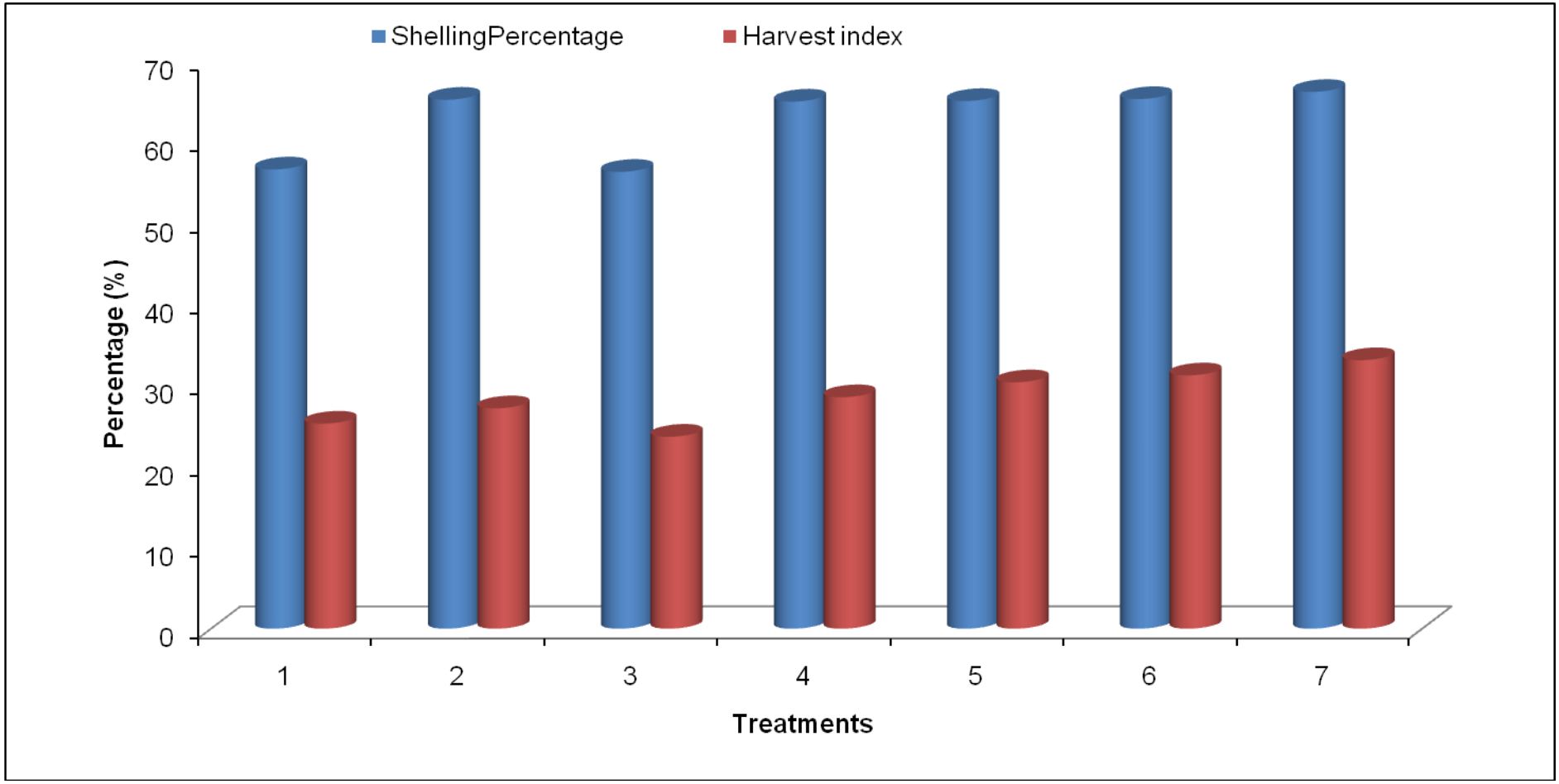


Fig.15: Shelling percentage and harvest index of different maize hybrids

Changes in soil properties

Chemical properties of soil *viz*., pH, Electrical conductivity, Organic carbon and available N, P, and K contents were determine before sowing (initial) and after harvest of crop under different treatments and presented in Table 17. Data clearly indicated that there is not any significant change occurs in soil pH, EC was recorded over their initial status.

The different treatments did not found to alter the various properties of soil significantly. Similarly it was noted that the various parameters did not show significant change over initial status.

Table 17. Initial properties and after harvest properties of soil as influenced by maize hybrids

Notation	Treatment	Soil pH	E.C. (ds/m)	O.C. (g/kg)	Available plant nutrients (kg/ha)		
					N	P	K
	Initial status	7.30	0.31	10.00	395.00	17.85	301.00
T_1	JKMH 502	7.30	0.33	10.00	383.43	16.90	295.25
T_2	JKMH 1701	7.30	0.33	10.00	385.08	16.64	296.25
T_3	JKMH 4545	7.30	0.33	10.00	391.27	17.40	297.50
T_4	JKMH 4023	7.30	0.32	10.00	389.37	16.60	296.65
T_5	JKMH 4025	7.30	0.31	10.00	384.73	17.70	295.50
T_6	JKMH 4029	7.30	0.31	10.00	390.44	17.10	298.50
T_7	JK Surabhi	7.30	0.33	10.00	391.40	17.30	299.00

Nutrients content and uptake

Nitrogen content in grain and stover

Data related to nitrogen content in grain and stover of maize is given in Table 18. It is clear from the data that the hybrid JK Surabhi having more nitrogen content in grain (1.96 %) and stover (0.81 %) as compared to other hybrids.

Phosphorus content in grain and stover

Data pertaining to phosphorus content in grain and stover of maize are presented in Table 18. Further, examination of data revealed that the hybrid JK Surabhi found maximum in phosphorous content in both grain and stover 0.087% and 0.48% respectively.

Potassium content in grain and stover

Data pertaining to potassium content in grain and stover of maize are presented in Table 18. A critical examination of data presented in Table 15 reveals that the hybrid JK Surabhi found maximum in potassium content in both grain and stover 2.36 % and 1.34% respectively.

Table 18. Nutrients content (%) in grain and stover of maize hybrids

Notation	Treatment	Nutrient content in Grain (%)			Nutrient content in Stover (%)		
		N	P	K	N	P	K
T_1	JKMH 502	1.87	0.056	1.16	0.52	0.32	0.95
T_2	JKMH 1701	1.26	0.081	1.98	0.76	0.43	1.02
T_3	JKMH 4545	1.24	0.061	1.31	0.54	0.36	0.74
T_4	JKMH 4023	1.74	0.077	1.89	0.66	0.37	0.86
T_5	JKMH 4025	1.84	0.082	2.12	0.79	0.46	1.11
T_6	JKMH 4029	1.95	0.076	1.85	0.75	0.42	0.87
T_7	JK Surabhi	1.96	0.087	2.36	0.81	0.48	1.34
	SEm±						
	CD(P=0.05)	**-**	**-**	**-**	**-**	**-**	**-**

Total uptake of major nutrients (N, P and K) uptake

Nutrient uptake was estimated for individual nutrient content in grain and stover. Their summation is also presented as total uptake by maize crop. The values of total N, P and K uptake (both in grain and stover) as influenced by different hybrids are given in Table 19 and Figure 16.

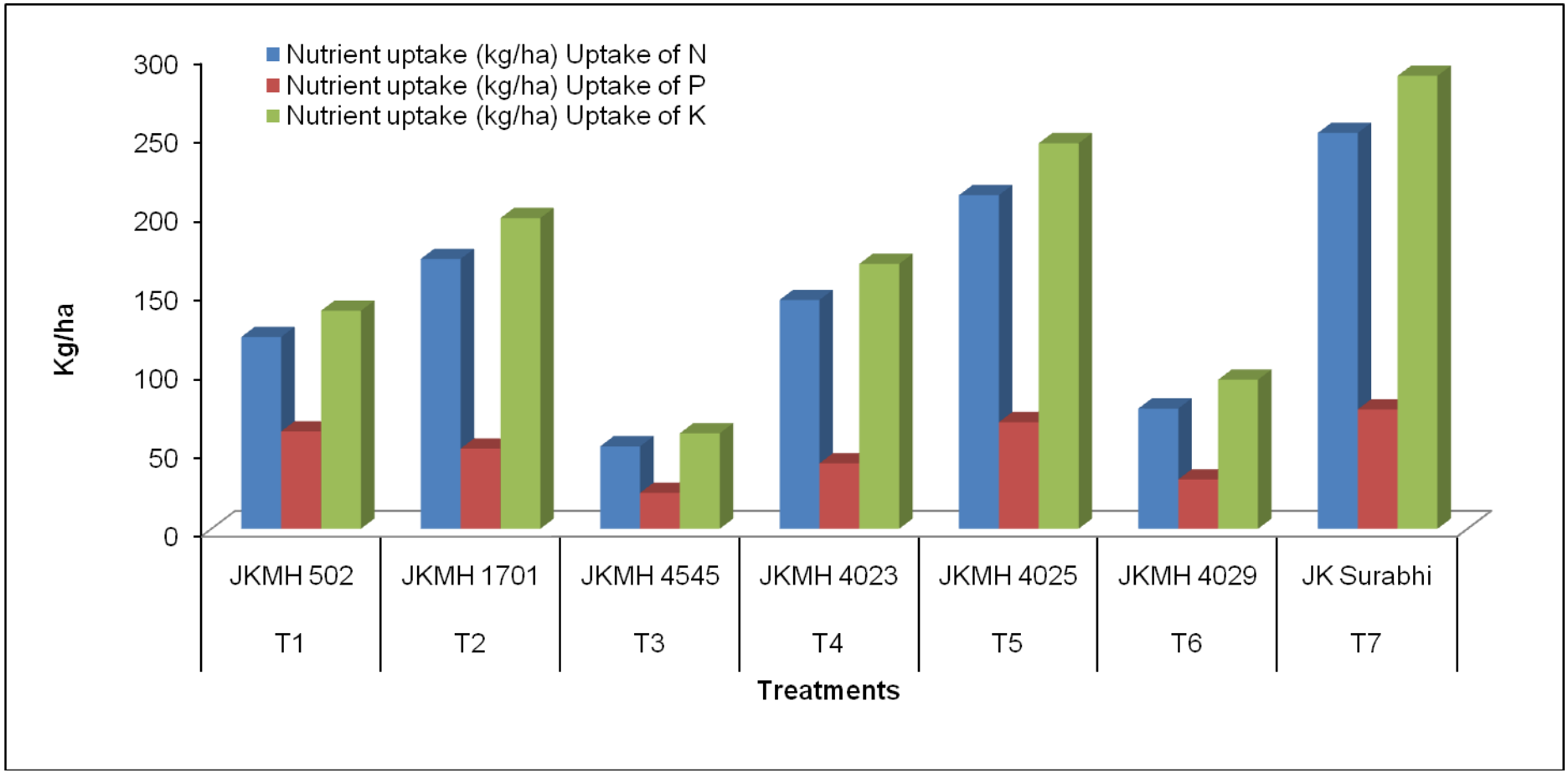


Fig.16: Total nutrient uptake (grain + stover) by maize hybrids

Table 19. Nutrients uptake by maize (grain + stover) by different hybrids

Notation	Treatment	Nutrient uptake (kg/ha)		
		Uptake of N	Uptake of P	Uptake of K
T_1	JKMH 502	121.76	61.81	138.43
T_2	JKMH 1701	171.29	50.90	197.22
T_3	JKMH 4545	52.31	22.77	60.65
T_4	JKMH 4023	145.27	41.52	168.18
T_5	JKMH 4025	211.76	67.67	244.75
T_6	JKMH 4029	76.36	31.36	94.65
T_7	JK Surabhi	251.30	75.79	287.56
	SEm±	**1.587**	**1.578**	**1.769**
	CD(P=0.05)	**4.893**	**4.864**	**5.453**

It is obvious from the data that total uptake of primary nutrients (N, P and K uptake) were significantly varied due to effect of different hybrid treatment. JK Surabhi had significantly highest total N, P and K uptake 251.80 kg/ha, 75.79 kg/ha and 287.86 kg/ha respectively. JKMH 4545 had the lowest total N, P and K uptake 52.31 kg/ha, 19.81 kg/ha and 60.55 kg/ha respectively.

Economics of the treatments

Data pertaining to economic analysis of different treatments viz., cost of cultivation, returns from the grains, returns from the stover, gross monetary returns(GMR), net monetary returns (NMR) and benefit-cost ratio (B:C ratio) are given in Table 19 and Figure 17.

Cost of cultivation

The package and practices for cultivation of maize crop was same for all treatments. The treatment cost of hybrids are same for all 7 treatments i.e. Rs. 28850/ha. Maize crop required an investment of Rs 23298/ha for common expenses in different operations and input. (Appendix III).

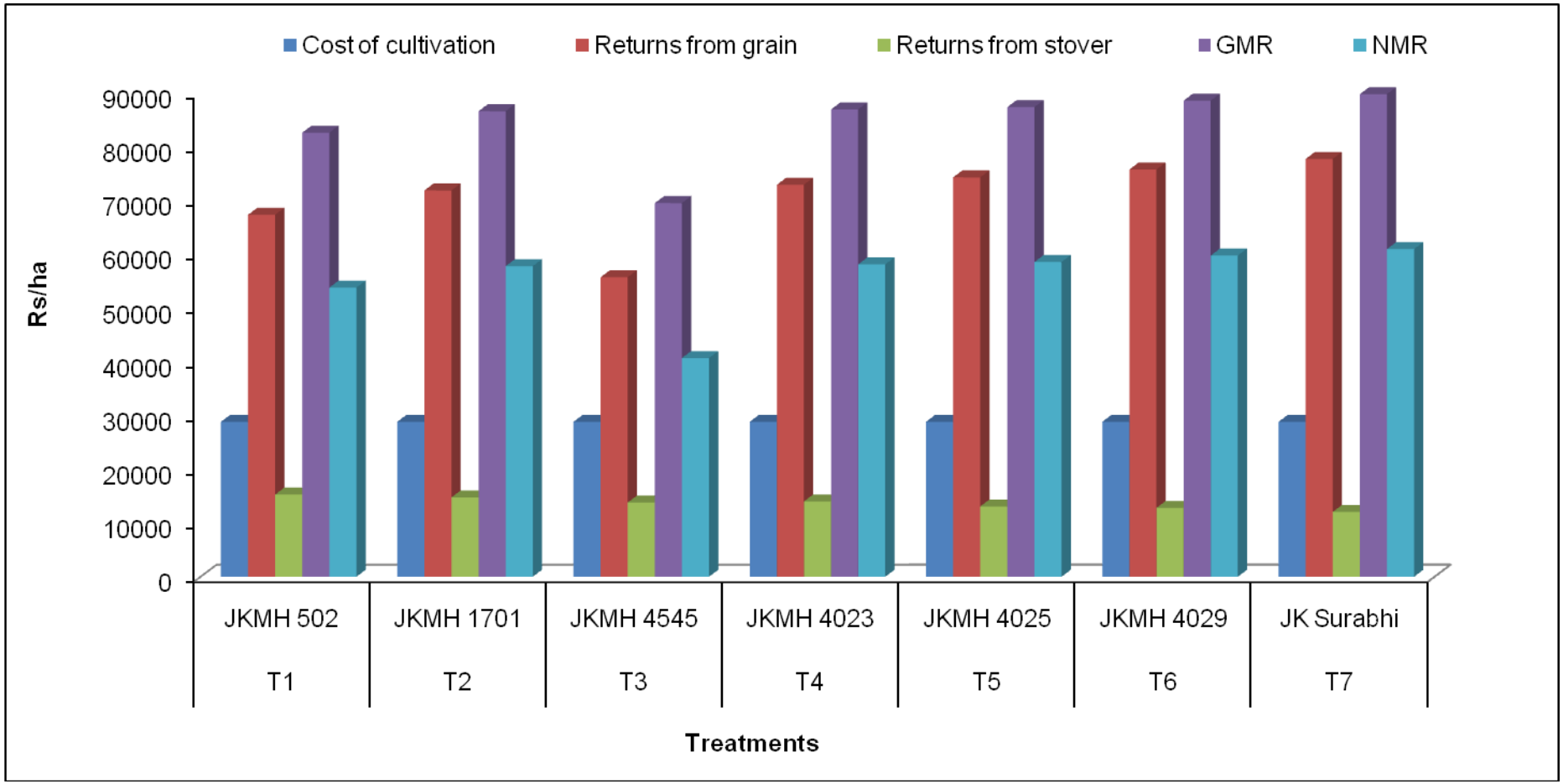


Fig.17: Economics analysis of different treatments

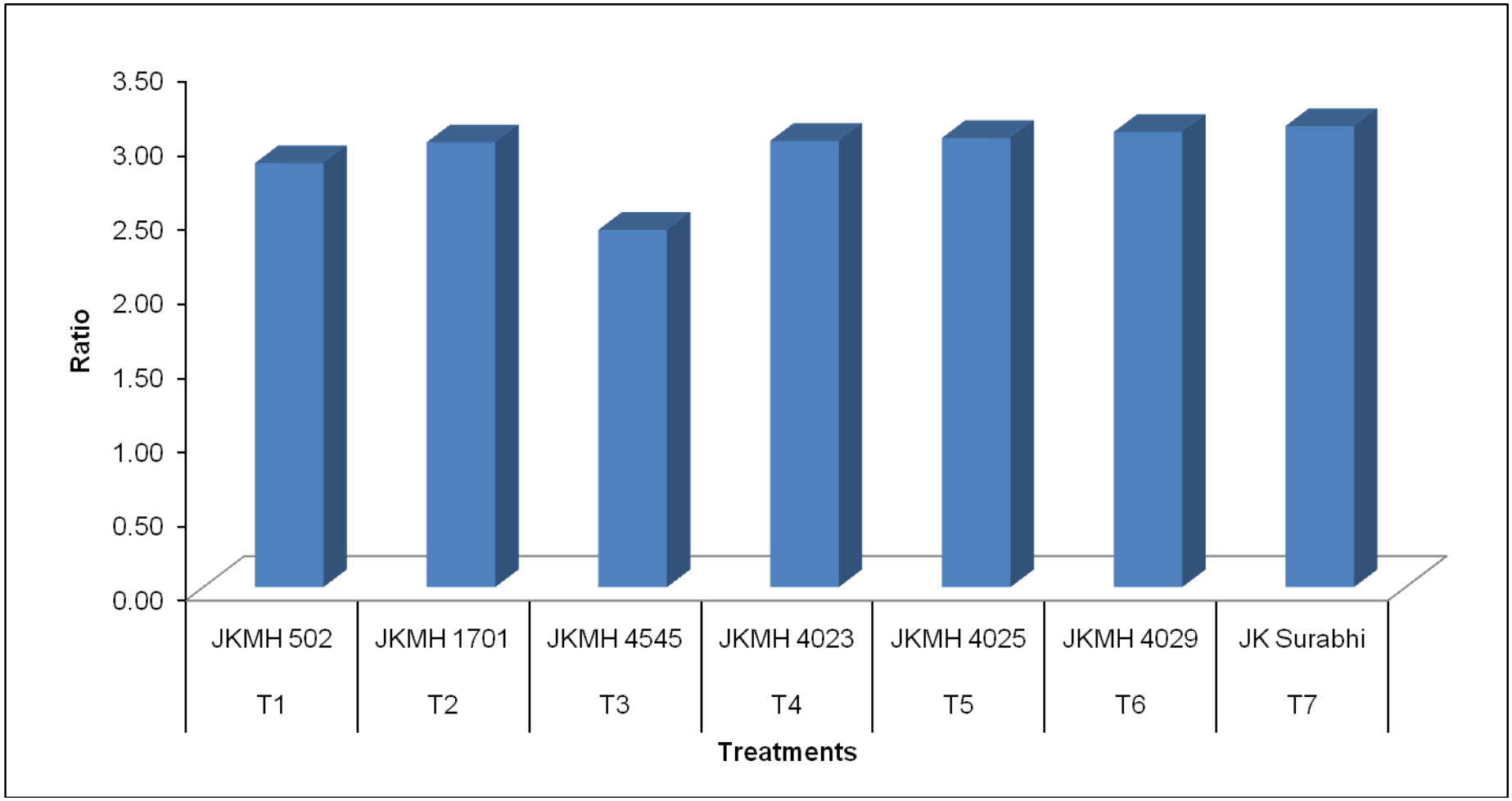


Fig.18: Benefit cost ratio of different treatments

Table 20. Economic analysis of different treatment on per hectare area basis

Notation	Treatment	Cost of cultivation (Rs/ha)	Returns from grain (Rs/ha)	Returns from stover (Rs/ha)	GMR (Rs/ha)	NMR (Rs/ha)	B:C Ratio
T_1	JKMH 502	28850	67392	15298	82690	53840	2.86
T_2	JKMH 1701	28850	71916	14768	86684	57830	3.00
T_3	JKMH 4545	28850	55757	13815	69572	40722	2.41
T_4	JKMH 4023	28850	72982	14030	87012	58162	3.01
T_5	JKMH 4025	28850	74360	13089	87449	58599	3.03
T_6	JKMH 4029	28850	75829	12824	88653	59803	3.07
T_7	JK Surabhi	28850	77792	12068	89860	61010	3.11

*Cost of seeds, for hybrid Rs 100/kg and selling price of seed Rs 1300/q and Stover Rs 100/q.

Gross monetary returns (GMR)

The GMR is the value of marketable produce under each treatment. It is directly related to the quantity of the produce obtained and existing rate of marketable produce under a particular treatment. It is evident from the data that the GMR was maximum (Rs 89860/ha) with hybrid JK Surabhi closely followed by T_6 JKMH 4029. The GMR was remarkably minimum (Rs 69572/ha) with hybrid JKMH 4545 among all treatments.

Net monetary returns (NMR)

Treatment JK Surabhi led to give maximum NMR of (Rs 61010/ha) among all treatments. The next best treatment was JKMH 4029 with NMR Rs 59803/ha. The NMR found in decreasing order with treatment T_5, T_4, T_2, T_1 and T_3. The hybrid Treatment JKMH 4545 fetched the minimum NMR (Rs 40722/ha) among all treatments.

Benefit: cost ratio

The B: C ratio varied among different treatments which are represented in Table 20 and Figure 18. The maximum B: C (3.11) ratio was recorded under the hybrid JK Surabhi. While the B: C ratio was found minimum (2.41) with hybrid JKMH 4545. Different treatments were in descending order of T_6, T_5, T_4, T_2, T_1 and T_3.

DISCUSSION

Maize is being a miracle crop of 21st century requires scrutiny of the new developed hybrids in comparison to existing ones under existing agro-climatic conditions of Kymore plateau and Satpura hill zone of Madhya Pradesh. Thus it is important to identify the production technology in relations to its growth behavior productivity, and economics. All these parameters were recorded in the field and laboratory and were presented in details in the experimental findings chapter. In this chapter the findings of the present investigation have been interpreted and discussed in the light of similar research carried out by other workers in India and abroad. The discussion is confined to relevant topics viz. weather conditions, plant population, morpho-physiological characters of hybrids, its quantitative parameters and finally the economics in relation to applied treatments in maize.

Effect of weather on crop

The crop plants are greatly affected by weather conditions during the crop season. Thus, the results of field experiment in agriculture are greatly influenced by weather conditions prevailing during the crop season. Therefore any discussion of experimental result would be incomplete without considering the crop- weather relationship to arrive at correct interpretation and conclusion. Weather details of temperature, relative humidity, sunshine hours and precipitation pertaining to the crop season are presented in Table 1 and Figure 1.

The meteorological parameters shows that during the crop season the sum of 1289.9 mm rainfall occurred in 55 rainy days. Most of the total rainfall occurred during the vegetative growth stages of crop and at ripening stages there was little rainfall which favored the crop growth.

Apart from this average maximum (44.8 ^{0}C) and minimum (14.4 ^{0}C) temperature, higher relative humidity (92 %) and good sunshine hours (2.3 – 10.4) prevailed during the crop season favoured the better growth and development of crop. Most of the precipitation during the peak demand of crop and a narrow difference between maximum and minimum temperature

also helped in filling of grain which ultimately resulted to produce higher grain yield.

Growth parameters

Plant population

The uniform plant density is an important requisite for obtaining higher precision when it is not a variable factor as the treatments. The data in Table 6 indicates that the plant population per m^2 remained non-significant under various maize hybrids without any definite trend. It ranges 6.57 to 6.63 per m^2 it is obviously reflected from these data that the sowing of hybrids was done properly, uniformly in each plot using healthy and viable seed to maintain the better crop stand. The germination potentiality of each hybrid was the same there was no any harmful effect of chemical fertilizer applied in the same furrow and seed were hand drilled on ridges.

Morphological characters

A linear increase in plant height was observed with the advancement in age of all maize hybrids. The height of all hybrids increased rapidly up to 60 day after sowing. The fast increase in plant height in the early stage of plant growth may be attributed to the higher number of leaves manufacturing higher food for growth, more and large leaves for preparing more food which increased cell division and resulted in rapid growth of the plants beyond 60 days, the plant height become slow till maturity stage which may be due to the fact that plant started entering form vegetative to the reproductive phase of growth and development. Thus it was also observed from the data that the increase in plant height continued up to maturity stage. Amongst from the hybrids, initially hybrid JKMH 502 attained maximum plant height at 30 DAS and later JKMH 1701 produces maximum plant height at every stage whereas, the hybrid JKMH 4545 recorded lowest plant height than other tested hybrids. These results are in close conformity with findings of Hussain *et al.* (2003), Khalil et al. (2005), Sorte et al. (2005), Malik et.al (2009), Hussain et al. (2011), Sivalaskshmi et al. (2012).

The maximum number of leaves per plant was progressively increased upto 60 days stage of crop with advancement in growth stage. The increase

may be probably due to simultaneous impact on the formation of leaves at every stage of observation.

The hybrids JK Surabhi produced higher number of leaves at every growth stages and were significantly superior to the remaining hybrids. The leaf area was non-significant at initial stage but found significantly higher in case of hybrid JK Surabhi at later stages. The dry weight production per plant was also found significantly higher in case of hybrid JK Surabhi. The production of dry matter in a hybrid is governed by the certain genetic factors associated with micro-climatic conditions of that area in which the plant grows. Hence, it varies from the variety to another. The hybrid respond in relation to growth parameters was also reported by Murariu et al. (1994), Babu et al. (1996), Sankar (2002), Sorte et al. (2005), and Sivalakshmi et al. (2012).

Physiological parameters

The basic principle behind this study is the estimation of crop growth at various stages and finally reasoning for yield variation. This would give an insight not only on performance of particular genotype, but also on the impact of superimposed agronomic practices on the crop at particular stage of growth as well as on the final yield. LAI, CGR, RGR and NAR were significantly different due to the effect of different treatments. The leaf area index was found to be non significant and net assimilation rate were found higher in JK Surabhi at all successive growth stages. The crop growth rate was increases upto 90 DAS very rapidly than it was slow down due to maturity. Relative growth rate shows the increment of crop biomass on the existing biomass. At initial stage it is higher but decline with the age of the plant. The LAI, CGR, RGR and NAR were significantly different due to the effect of different treatments at all successive growth stages. (Kumar and Singh (1999), Yakadri and Rao (2003), Sorte et. al (2005), Akram et. al (2010) and Parihar (2012).)

Yield attributes and yield

The yield of maize per unit area influenced to a greater degree by the number of cobs per plant. More number of cobs per plant leads to higher grain yield.

The grain rows per cob (14) was found higher in JKMH 4029, number of grain rows per cob (27.00) was found higher in JKMH 502, and total grain per cob (322.08) were found significantly higher in hybrid JKMH 4025. Kumar et. al (2002), Tahir et. al (2008), Malik et al. (2009), Singh and Chauhan (2010).

Grain is the final product of cumulative effect of all the factors contributing to growth and development whereas seed index is a parameter which describes the boldness of the size of the seed expressed as 100 grain weight. The varietal effects were found to be significant. The hybrid JK Surabhi recorded significantly higher seed index (33.33 g) showing bigger size than most of the tested hybrids. There after the hybrids JKMH 1701, JKMH 502, JKMH 4023, JKMH 4029 (32.00 g, 30.00 g, 30.33 g, 30.67 g) perform equally well in this parameter. The hybrid JKMH 4025 recorded the lowest value of seed index (27.33 g). The variation in seed size among the varieties may account to variable genotypic in heritance. The harvest index is the ratio of economic yield to biological yield. The maximum harvest index was found in JK Surabhi (33.14%) and shelling percentage was also found maximum in hybrid JK Surabhi 66.24% respectively. The similar result trend were also reported by Bolanas (1994), Maizia Dixon et al. (2000), Kumar et al. (2002), Tahir et al. (2008), Malik et al.(2009), Singh and Chauhan (2010) and Sobhana et al. (2012).

Grain and stover yield

Grain yield per hectare is the final expression of physiological and metabolic activities of a plant and a product of cumulative action of all factors contributing to batter growth viz. number of cobs per plant, grains par cob and seed index. Yield is a complex trait and exhibits continuous variation, such continuous variation being generally attributed to polygenic control. Yield is governed not only by polygene but also highly influenced by environmental fluctuations. It is evident that the genotypic effect on grain yield was significant. The hybrid JK Surabhi produced significantly higher grain yield (59.84 q/ha) and higher stover yield (152.98 q/ha) produce by JKMH 502 than the other tested hybrids. These results were collaborated with the findings of Malhi et al.(1993), Cord (2000), Pardo and Filho (2000), Hussain et al. (2003),

Singh and Singhi (2006), Jogdand et.al (2008), Tahir et.al (2008), Jadhav and Shalke (2009), Malik et al. (2010), Pal and Bhatnagar (2009), Akram et al. (2010), Aziz et al. (2011), Biradar et al. (2011), Nepaliya et al. (2012) and Saqib (2012).

Total Uptake of Major (NPK) nutrients

Data on uptake of major (NPK) nutrients by the crop under a particular set of production technique reflect the quantity of nutrients absorbed or removed by the crop to reach its final stage. Normally the nutrients are removed by the crop through its biomass (grain + stover) production therefore, concentration of a nutrient in biomass and quantity of biomass production affect the total quantity of removal of a particular nutrient. Thus, the total uptake of any nutrient by both crop components as a whole significantly differed mainly due to their biological yields. The uptake of N, P and K were found maximum in case of hybrids JK Surabhi. It shows that this hybrid is more responsive than all remaining tested hybrids on the same dose of fertilizer. The hybrid response in relation to nutrient uptake was also reported by Empig and Zuno (1984), Mishra (1993), Tollenaar et. al (1994), Shanti et.al (1997), Padmja et. al (1999), Geetha (2000), and Shobhna et. al (2012).

Economics of the Treatments

The economic analysis of the treatment has its importance from practical point of view to the farmers. Any production technology may not be useful for the farmers, provided it is not economically viable. Several economical factors such as cost of cultivation, total monetary gains, net profits and profitability etc. of any production technology may be acceptable to the user. The above mentioned economic factors were estimated on per hectare area basis by considering the existing market values of different inputs and output. Therefore, to evaluate the total cost of cultivation, the cost involved for growing crop were taken into consideration in the present investigation. The common cost of cultivation for maize crop was Rs 28850/ha for all treatments (Appendix-I).

The Gross monetary returns was maximum (Rs 89860 /ha) with JK Surabhi followed by JKMH 4029 (Rs 88653 /ha). The GMR was remarkably

minimum (Rs 69572/ha) with T_3 among all treatments. Treatment T_7 led to record maximum NMR (Rs 61010/ha) among all treatments. The next best treatment was T_6 with NMR of Rs 59803/ha.The benefit-cost ratio varied among different treatment. The B:C ratio found maximum in hybrid JK Surabhi (3.11). JKMH 4545 fetched the minimum B:C ratio (2.41) among all the treatments. These results are in close conformity with the findings of several workers, Kumar *et. al* (2002), Thakur *et. al* (2003), Singh and Singhi (2006), Jadhav and Shalke (2009), Pal and Bhatnagar (2009), Karim et.al (2010). Pal and Bhatnagar (2012), and Saqib et.al (2012).

SUMMARY, CONCLUSIONS AND SUGGESTIONS FOR FURTHER WORK

Summary

The present investigation entitled “Relative performance of newly developed maize hybrids” was conducted at the Product testing unit, Department of Agronomy College of Agriculture JNKVV, Jabalpur (M.P.) during kharif 2014. The objectives of the present investigation were as follows:

1. To find out the suitable maize hybrids in vertisol under rainfed condition
2. To access the nutrient uptake of different maize hybrids under rainfed ecosystem
3. To work out the economics of treatments.

The soil of experiment field was sandy clay loam in texture with the pH of 7.3. The soil was medium in available nitrogen (395 kg/ha), medium in available phosphorus (17.85 kg/ha), medium in available potassium content (301 kg/ha) and 1.50 percent carbon with 0.31 ds/m at 25^0C electrical conductivity. The total rainfall received during the crop season was 1289.9 mm. The mean minimum and maximum temperature varies between 14.4 ^{0}C to 44.8 ^{0}C respectively. The relative humidity of the tract is ranged between 33 to 92 percent in morning and 12 to 79 percent in evening.

The experiment consisted of 7 hybrids of maize under rainfed condition and was laid out in a randomized block design with 3 replications. The gross and net plot sizes were 5.0 m X 3.6 m and 4.0 m X 2.4 m, respectively. The seeds of maize were sown and fertilizer was applied on 11 July 2014. Hybrids are growing under rainfed conditions are as detailed below:

A number of maize (*Zea mays* L.) hybrids have been developed recently and are now available in Madhya Pradesh. These hybrids are suited to different agro-climatic conditions and available inputs like irrigation and fertilizer. In view of declining area and poor productivity of maize in M.P.,

choice of suitable variety after a good scope to enhance the production potential of rainfed maize in M.P. Therefore, a study was carried out on these aspects.

The important findings obtained from the present investigation are summarized below:

T_1 JKMH 502

T_2 JKMH 1701

T_3 JKMH 4545

T_4 JKMH 4023

T_5 JKMH 4025

T_6 JKMH 4029

T_7 JK Surabhi

Morphological characters

The plant height (cm) recorded at 30, 60, 90 DAS and maturity was significantly influenced by different treatments under rainfed condition. Treatments T1 was found significantly superior to other treatments. AT 30DAS hybrid JKMH 502 found the highest plant height (15.76cm). At 60, 90 DAS and at maturity JKMH 1701 recorded the highest plant height, (168.42 cm) at 60 DAS, (180.06 cm) 90 DAS and at maturity (179.02 cm) stages which are superior to other treatments. The lower plant height was recorded in hybrid JKMH 4545 at all stages 11.80 cm at 30 DAS, 122.24 cm at 60 DAS, 137.80 cm at 90 DAS and 135.20 cm at maturity stages. JK Surabhi recorded significantly higher dry weight per plant over the rest of the treatments at different successive growth stages (30, 60, 90 DAS and maturity).

The hybrid JK Surabhi recorded significantly higher number of leaves per plant at all the successive growth stages (30, 60, and 90 DAS) and proved significantly superior to most of the treatments. The same result found in leaf area (m^2) the hybrid JK Surabhi resulted in significantly greater values than others.

Growth analytical characters

Hybrids were differed significantly for all the growth analytical characters viz. Leaf area index (LAI), Crop growth rate (CGR), Relative growth rate (RGR), Net assimilation rate (NAR). The growth analytical characters LAI, NAR and CGR had better expression under hybrid JK Surabhi at different successive growth stages. Whereas for RGR the values varies with different days stages at initially 60 and 90 DAS the hybrid JK Surabhi shows higher RGR and at maturity the hybrid JKMH 1701 shows highest RGR.

Yield attributing characters

Hybrids were differed significantly for the entire yield attributing characters viz. number of cobs per plant, grain rows per cob, grains per row, cob weight (g), seed index etc. The yield attributing characters had better expression JK Surabhi under rainfed condition. This resulted in an increase in cob bareness and grains per cob which ultimately led towards an increase in economic yield. The higher cob length (16.23cm) was shown by JK Surabhi and maximum cob girth (15.01 cm) was found in case of hybrid JKMH 4545.

The treatment JK Surabhi recorded higher higher grain weight (91.06 g), higher number of rows per cob (12), highest number of grain per rows (23.01), total grains per cob (276.23), and higher 100 grain weight (33.33 g) respectively.

Grain and stover yields

Hybrids were differed significantly for grain and stover yields. The significant highest grain yield of rainfed condition was recorded (59.84 q/ha) from hybrid JK Surabhi as compared to other hybrids. However, the second best treatment was recorded (58.33 q/ha) from T_6 (JKMH 4029) as compared to other treatments. The lowest grain yield was recorded 42.89 q/ha from hybrid JKMH 4545. The treatments JKMH 502 recorded the higher stover yield (152.98 q/ha) than remaining treatments. JK Surbhi recorded lowest stover yield (120.68 q/ha).

The shelling percentage was found significantly higher in case of Hybrid JK Surabhi (66.24%). The lowest shelling percentage was found in

case of hybrid JKMH 4545 (56.38%). The harvest index of maize was also recorded significantly higher due to hybrids. The highest harvest index was observed in JK Surabhi (33.14%). Lowest harvest index was observed in JKMH 4545 (23.69%).

Total uptake of major nutrients (NPK)

Hybrids were differed significantly for total uptake of major nutrients (NPK). The significant highest total N, P and K uptake (both in grain and stover) varies with hybrids. The hybrids JK Surabhi was recorded highest total N uptake (275.85 kg/ha), total uptake of P (75.79 kg/ha) and total K uptake (287.86 kg/ha) as compare to other treatments.

Economic of treatments

The GMR was maximum (Rs. 89860/ha) with JK Surabhi closely followed by JKMH 4029 (Rs. 88653/ha). The GMR was remarkably minimum (Rs. 69572/ha) with JKMH 4545 among all treatments.

Treatment JK Surabhi recorded maximum NMR (Rs. 61010/ha) among all treatments. The next best treatment was JKMH 4029 with NMR of Rs. 59803/ha. JKMH 4545 (Rs. 40722/ha) fetched the minimum NMR among all treatments.

Conclusion

1. Amongst the different hybrids of maize, hybrids JK Surabhi give maximum seed and stover yield.
2. JK Surabhi hybrid is more responsive to applied nutrients. The uptake of N, P and K was found maximum in case of JK Surabhi hybrid.
3. The NMR (Rs 61010/ha) and B:C ratio (3.11) was higher with hybrid JK Surabhi followed by hybrid JKMH 4029 (Rs 59803/ha) NMR and (3.07) B:C ratio.

Suggestion for further research work in future

1. To confirm the results under rainfed condition in the changing climatic conditions, the experiment should be repeated for a few more years.
2. To work out at the year wise variable price levels of maize grain as well as agro-inputs so that these may be accounted for any fluctuations in the market price.
3. To exploit the full potential of maize more hybrids should be tested.

BIBLIOGRAPHY

Abbas MA. 2001. Genetics and crop improvement. In General Agriculture. 2nd. Emporium publisher. 218.

Ahmad K, Rahman, Hidayat UR, Waqar A and Hussain N. 2004. Performance of maize hybrids for yield and yield components. Sarhad Journal of Agriculture 20 (3): 405-408.

Akram, Ashraf M, Waraich MY, Hussain EA, Hussain M, Mallahi N, AR. (2010). Performance of autumn planted maize (*Zea mays* L.) hybrids at various nitrogen levels under salt affected soils. Soil and Environment. 29 (1): 23-32.

Anonymous. 2011. Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India. http://www.agricoop.nic.in/Agristatistics.htm

Ashraf MA, Waraich MY, Hussain EA, Hussain M, Mallahi N, AR. 2010. Performance of autumn planted maize (*Zea mays* L.) hybrids at various nitrogen levels under salt affected soils. Soil and Environment. 29 (1): 23-32.

Aziz MA, Rahman AKMM, Chakma R, Ahmed M and Ahsan AFMS. 2011. Performance of Bari hybrid maize varieties in the hilly areas of Bangladesh. J. Expt. Bioscience 2(2): 25-28.

Babu R, Gumaste SP, Jayanna SJ, Patil MTC. 1996. Performance of sheeramrutha - a high yielding forage maize variety for Karnataka. Karnataka Journal of Agricultural Sciences. 9 (1): 1-6.

Beadle CL. 1985. Plant growth analysis. The technique in bioproductivity and photosynthesis (ed.) by Coobs, J.C. hall, D.P., Long, S.P. and Scurlo C.O., J.M.O. Pergamon Press. pp: 20-25

Biradar SR, Kotikal YK, Balikai RA and Biradar DP. 2011. Comparative performance of maize hybrids against major insect pests. Karnataka Journal of Agricultural Sciences, 24 (4): 540-541.

Black CA. 1965. Method of soil analysis Part 1. Am. Soc. Agron. Inc. Public. Madison Wisconsin USA.

Bolanos J. 1994. Physiological basis of the genetic progress on corn *(Zea mays L.)* cultivars from the Regional Maize Programme. [Spanish]. Agronomia Mesoamericana. 5: 67-77.

Chapman HD and Partt PF. 1961. Soil water and plant analysis. Univ. California, Agri. Div. Publication.

Chaudary AR. 1983. Maize in Pakistan Punjab Agriculture Research Coordination Board, University of Agriculture, Faisalabad.

Corb V. 2000. Performance of some early maize hybrids under the conditions of North-Western Romania. Analele Institutului de Cercetari pentru Cereale si Plante Tehnice, Fundulea. 67: 73-79.

Devi P and Singh NK. 2008. Behaviour of maize inbreds and hybrids across diverse environmental regimes. Indian Agriculturist 52 (3/4): 169-173.

Dixon M, Kling BB, Okoruwa JG, AE. 2000. Physical, chemical, and water absorption characteristics of tropical maize hybrids. African Crop Science Journal. 2000. 8 (4): 419-428

DMR. 2008. Vision 2025. Directorate of Maize Research, Pusa Campus, New Delhi pp-42.

Empig LT, Zuno JC. 1984.Grain yields of corn hybrids under various levels of NPK fertilization. Philippine Journal of Crop Science, 1984. 9 (2): 129-133.

Gangwar S. Naik, Nayak KR, Siddarth, Koutu KG and Verma N. 2012. Impact of geometry and fertility levels on productivity of hybrid maize. In: Extended Summaries Vol 2: 3rd International Agronomy Congress, Nov.26-30, 2012, New Delhi. pp 374-375.

Gardner FP, Pearcher RB and Mitchell RL. 1985. Growth and development In. physiology crop plant . The Jawa state uni. Press pp 187-208.

Geetha K. 2000. Per se performance of parents and hybrids in maize for grain yield characters. Madras Agricultural Journal 87: 1/3, 57-60.

Gregory FG. 1926. The effect of climatic conditions on growth of barley. Ann. Bot.,40:1-6.

Hussain N, Khan MY and Baloch MS. 2011. Screening of maize varieties for grain yield at Dera Ismail Khan. The Journal of Animal & Plant Sciences 21(3): 626-628

Hussain N, Hayat K, Khan FU, Abdul A and Zaman Q. 2003. Evaluation of different maize varieties under agro ecological condition of D.I. khan. Sarhad journal of agriculture 19(4): 539-542.

Ignat C, Burloi G, Diaconu P. 1996. Cercetari privind potentialul productiv al unor hibrizi de porumb in culturi succesive. Lucrari Stiintifice - Universitatea de Stiinte Agronomice Bucuresti. Seria A, Agronomie 39: 23-28.

Ijaz-Ul-Hassan S, Tariq M and Islam N. 2011. Performance evaluation of promising yellow maize hybrids in distinct agro-ecological domains of central Punjab, Pakistan, J. Agric. Soc. Sci. 7 (4): 143–146

Izge AU and Dugje IY. 2011. Performance of drought tolerant three-way and top cross maize hybrids in Sudan Savanna of North Eastern Nigeria. Journal of Plant Breeding and Crop Science 3 (11): 269-275.

Jackson ML. 1973. Soil Chemical Analysis. Prentice Hall of India Private Limited,New Delhi.

Jadhav VT and Shelke DK. 2009. Influence of land configurations and fertilizer levels on production potential of maize hybrids in vertisol under rainfed conditions. Journal of Maharashtra Agricultural Universities 34 (1): 1-3.

Jogdand PB, Kadam GL, Talnikar AS, and Karande DR. 2008. Response of maize (*Zea mays L*.) hybrids to fertility levels in kharif season. International Journal of Agricultural Sciences 4(1): 225-230

Jyoti K, Gadag RN and Jha GK. 2006.Identification of potential early maturing single cross maize (*Zea mays*) hybrids. Indian Journal of Agricultural Sciences, 76 (6): 383-385.

Karim MR, Moniruzzaman M and Alam QM. 2010. Economics of hybrid maize production in some selected areas of Bangladesh. Bangladesh Journal of Agricultural Research, 35 (1): 83-93.

Kertikova D, Kertikov T. 2011. Investigation of economic characteristics of maize hybrids from the FAO mid-late and late group: II. Suitability of the hybrids for production of biomass-silage. [Bulgarian]. Selskostopanska Nauka (Agricultural Science) 44 (5): 35-42.

Khalil, Ibni A, Hidayat Ur Rahman, Naveed-Ur-Rehman, Arif M, Iftikhar HK, Iqbal M, Hidayatullah, Khilwat A, Sajjad M and Ishaq M. 2011. Evaluation of maize hybrids for grain yield stability in North-West of Pakistan. Sarhad journal of agriculture Vol.27 (2): 213-218.

Koenig RA and Johanson CR. 1942. Colorimetric determination of phosphorous in biological materials. Indian Engg. Chem. Anai, 14: 155-156.

Kumar SN and Singh CP. 1999. Yield and yield components of maize (*Zea mays* L.): physiological analysis on seasonal variations. Indian Journal of Plant Physiology 4 (2): 90-94.

Kumar A, Thakur KS and Manuja S. 2002. Effect of fertility levels on promising hybrids maize *(Zea mays* L.) under rainfed condition of Himachal Pradesh. Ind.J. of Agr . 47 (a): 526-530.

Kumar A. 2010. Prediction of double cross hybrid performance in maize (*Zea mays* L.). Electronic Journal of Plant Breeding 1(4): 712-715.

Kurdikeri MB, Aswathaiah B, Rajendraprasad S. 1998. Influence of seed size on field performance in maize hybrids (*Zea mays* L.). Seed Research 26: (1) 23-27.

Mahajan, Chikkappa V, Kumar GK, Kumar B, Ahmad RSB, Manivannan, Kumar V. 2012. Performance of single cross maize hybrids during winter season of northern India. Indian Journal of Genetics and Plant Breeding 72 (3) 372-375.

Malhi NS, Dhillon BS, Saxena VK, Sharma SR. 1993. *In*: symposium on Relative performance of single and double cross hybrids in maize. Heterosis breeding in crop plants - theory and application, 23-24 February 1993, Ludhiana 36-37.

Malik Haq Nawaz, Iffat Ara, Muhammad Naeem, Mozammil Hussain, M. Hanif Munawwar and Yousaf M, (2010). Comparison of open pollinated varities and newly developed hybrids for yield and yield contributing traits in maize. Pakistan j. Agric.Res. **23** (1-2): 37-41

Mascagni HJ, Kang Jr, Burns MS, DR. (1995). Performance of early maturity corn hybrids in North Louisiana. Louisiana Agriculture 38 (4): 11-12.

Mishra CM. 1993. Performance of Maize (*Zea mays* L.) varieties to fertility levels under rainfed conditions of Madhya Pradesh. Indian Journal of Agronomy 38(3): 483-485.

Muhammad A., Tahir M., Tanveer A., Ali A. and Wasaya A. 2008. Comparative yield performance of different maize (*Zea mays* L.) hybrids under local conditions of Faisalabad (Pakistan). Pakistan Journal of Life Science 6(2): 118-120.

Murariu M, Cristea M, Dutu H. 1994.Performance of some experimental silage maize hybrids at the Agricultural Research Station, Suceava. [Romanian*]* Cercetari Agronomice in Moldova 27(1-2): 53-57.

Nawaz MH, Ara I, Naeem M, Hussain M, Hanif Munawwar M and Yousaf M. 2010. Comparison of open pollinated varities and newly developed hybrids

for yield and yield contributing traits in maize. Pakistan j. Agric.Res. 23 (1-2): 37-41.

Nazir H, Khan F, Ahamd E, Khan AA and Zaman Q. 2006. Evaluation of corn hybrids under agro-ecological conditions of D.I. Khan. Sarhad J. Agric. 22: 633–636

Nepaliya V, Singh D and Chouhan GS. 2012. Performance of maize varieties under varying environments. *In.* Extended Summaries Vol. 3: *3rd International Agronomy Congress,* Nov. 26-30, 2012, New Delhi, India pp 1155-1156.

Olakojo SA and Iken JE. 2001. Yield performance and stability of some improved maize varieties. Moor J. Agric. Res. 2: 21-24.

Olaoye G. 2009. Evaluation of new generations of maize streak virus (msv) resistant varieties for grain yield, agronomic potential and adaptation to a southern guinea savanna ecology of Nigeria. *J.* Trop. Agric. Food,Environ. & Ext. 8 (2): 104-109.

Olsen SR, Cole CV, Vatanabe FS and Dean LA. 1954. Estimation of available phosphorous in soil by extraction with sodium bicarbonate. Circ.U.S. Dept. Agric. 939:1-19.

Padmaja M, Sreelatha D, Rao KL. 1999. Effect of nitrogen on nutrient uptake in maize (*Zea may* L.) types. Journal of Research ANGRAU 27(4): 112-114.

Pal MS and Bhatnagar A. 2012. Productivity and profitability of pop corn, composite and hybrid maize (*Zea mays* L.) under low nitrogen stress in mollisols of Uttarakhand. Madras Agricultural Journal 99 (4/6): 59-262

Pal MS and Bhatnagar A. 2009. Production potential and economics of winter maize (Zea mays) cultivars in Tarai belt of Uttarakhand. Current Advances in Agricultural Sciences (1) 14-16.

Parihar AK, Godawat SL, Shukla KB and Parihar CM. 2012. Performance of quality protein maize (*Zea mays*) genotypes under different moisture-stress environments. Indian Journal of Agricultural Sciences 82 (5): 416-421.

Piper CS. 1950. Soil and plant analysis. Intel. Science Publishers, Inc. New York.

Pooja D. and Singh NK. 2008. Behaviour of maize inbreds and hybrids across diverse environmental regimes. *Indian Agriculturist* 52 (3/4): 169-173.

Porto MP and Storck L. 2003. Comportamento de hibridos comerciais de milho em solos hidromorficos, no estado do Rio Grande do Sul. Revista Brasileira de Milho e Sorgo 2 (1): 34-42.

Prado R. de M, Goulart Filho LR. 2000. Performance of twenty maize hybrids under late sowing in a quartzipsamment area of the Triangulo Mineiro savanna. Revista de Agricultura (Piracicaba) 75 (1): 29-39.

Russel WA. Contribution of breading to maize improvement in United States 1920s-1980s. Lowa State J.Res. 1986, 61: 5-34

Sankar GRM, Reddy PR, Venkateswarlu S. 2002. Statistical assessment of performance of maize (*Zea mays*) genotype in alfisols. Indian Journal of Dryland Agricultural Research and Development 17 (2): 104-108.

Saqib M, Zamir MSI, Tanveer A. and Ahmad A.U.H. 2012. Agro-economic evaluation of various maize hybrids under different planting patterns. Cercetari Agronomice in Moldova 45 (3): 63-70.

Shah P, Worzella WW and Nasr GH. 1982. Performance of corn hybrids at varying plant population. Pakistan Journal of Agricultural Research 3 (1): 6-12.

Shanti K, Rao VP, Reddy M R, Reddy MS, Sarma PS. 1997. Response of hybrid and composite maize (*Zea mays*) to different levels of nitrogen. Indian Journal of Agricultural Sciences 67 (8): 326-327.

Shivalaxmi V, Sreelatha D, Pradeep T and Kumar S. 2012. Performance of maize hybrids under different plant densities. Maize Journal 1 (1): 67-69.

Shobhana V, Kumar Idnani A, Singh LK, Inshwer and Shivadhar. 2012. Plant population and nutrient requirement for baby corn hybrids (*Zea mays*). Indian Journal of Agronomy 57 (3): 294-296.

Singh D and Singhi SM. 2006. Response of early maturing maize (Zea mays) hybrids to applied nutrients and plant densities under agroclimatic conditions of Udaipur in Rajasthan. Indian Journal of Agricultural Sciences 76 (6): 372-374.

Singh SB, Sharma MM, Singh AK.2009. Stability analysis for grain yield and yield-contributing traits in maize (*Zea mays*) single cross hybrids under mid hills. Indian Journal of Agricultural Sciences 79 (11): 890-896.

Singh, Indrakumar N. and Chauhan JS. 2010. Evaluation of Quantitative Physiological Traits of Some Hybrid Maize. *World Journal of Agricultural Sciences* 6 (3): 297-300.

Sorte NV, Phad KM, Sripriya Balachandran More MB, Anitha C. 2005. Evaluation of maize composites on their morpho-physiological performance. Journal of Soils and Crops 15 (2): 452-456.

Subbiah BV. and Asija AS. 1956. A rapid procedure for the estimation of available nitrogen in soil. Curr. Sci. 25:258-260.

Tahir M, Tanveer Asif, Ali Asghar, Abbas Muhammad and Wasaya Allah (2008). Comparative yield performance of different maize (zea mays l.) hybrids under local conditions of Faisalabad. Pakistan. Pakistan journal of life Science. **6** (2): 118-120.

Thakur HS, Girothia OP, Holkar S and Sharma RA. 2003. Effect of land treatments on productivity of rainfed maize (Zea mays L.) varieties grown on vertisol of Madhya Pradesh. Crop Research (Hisar) 26 (1): 75-78.

Tollenaar M, Nissanka SP, Aguilera A, Weise SF, Swanton CJ. 1994. Effect of weed interference and soil nitrogen on four maize hybrids. Agronomy Journal 86 (4): 596-601.

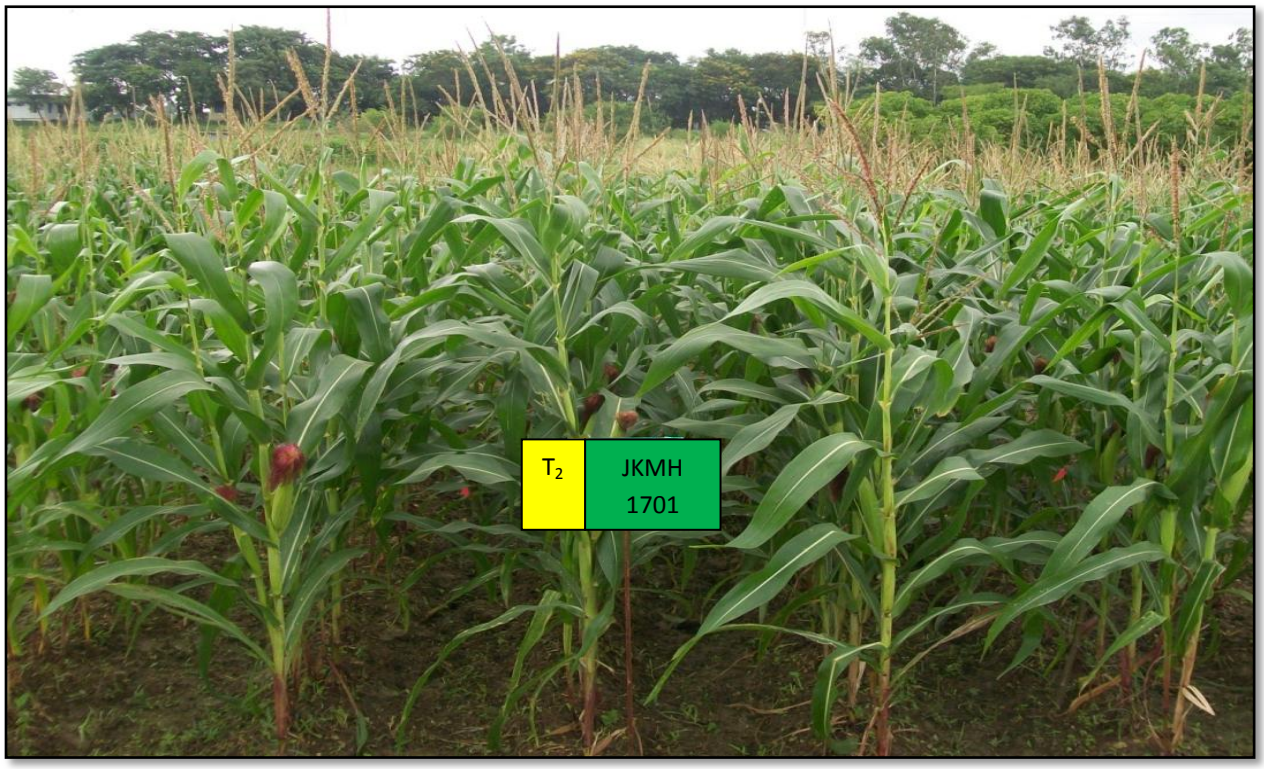
Trethowan RM, Crossa J, Ginkel M. and Rajaram S. 2001. Relationships among bread wheat international yield testing locations in dry areas. Crop Sci. 41: 1461-1469.

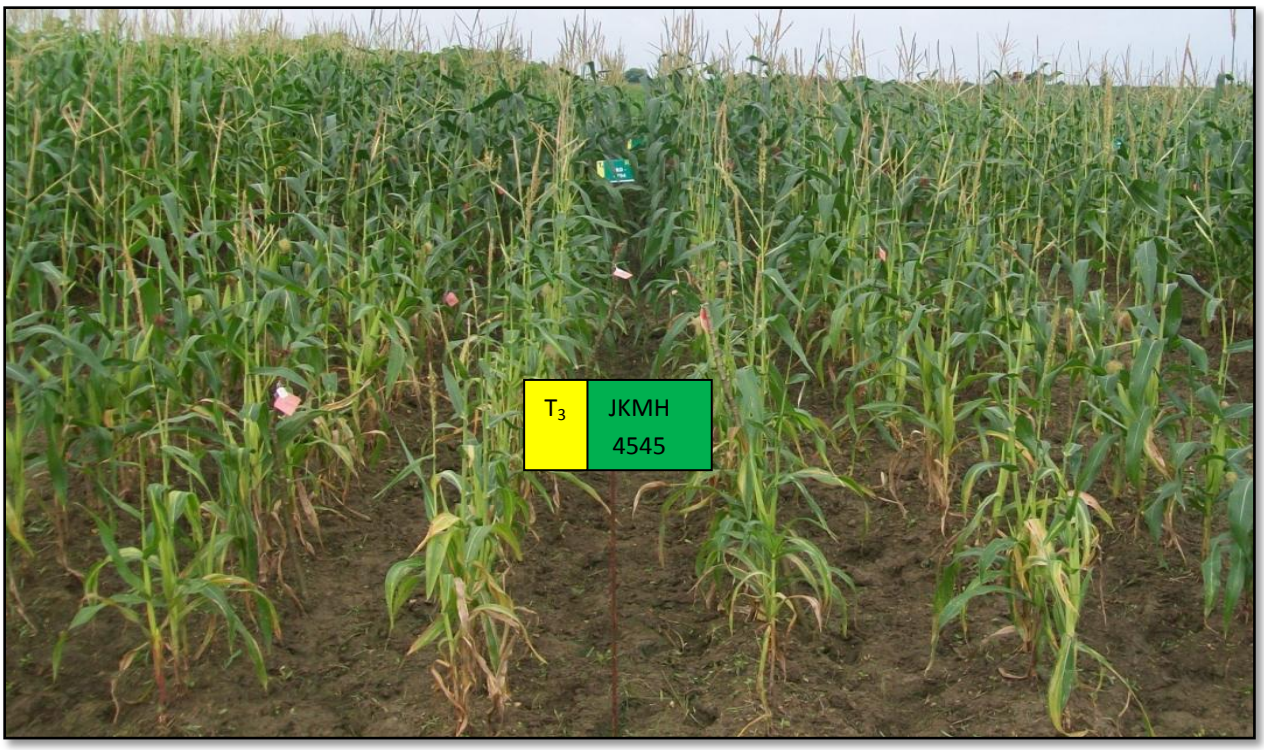
Vieira RA, Rodovalho M. de A, Scapim CA, Tessmann DJ, Amaral Junior AT and Bignotto LS. 2009. Agronomic performance of new popcorn hybrids in northwestern Parana state, Brazil. Acta Scientiarum - Agronomy 31(1): 29-36.

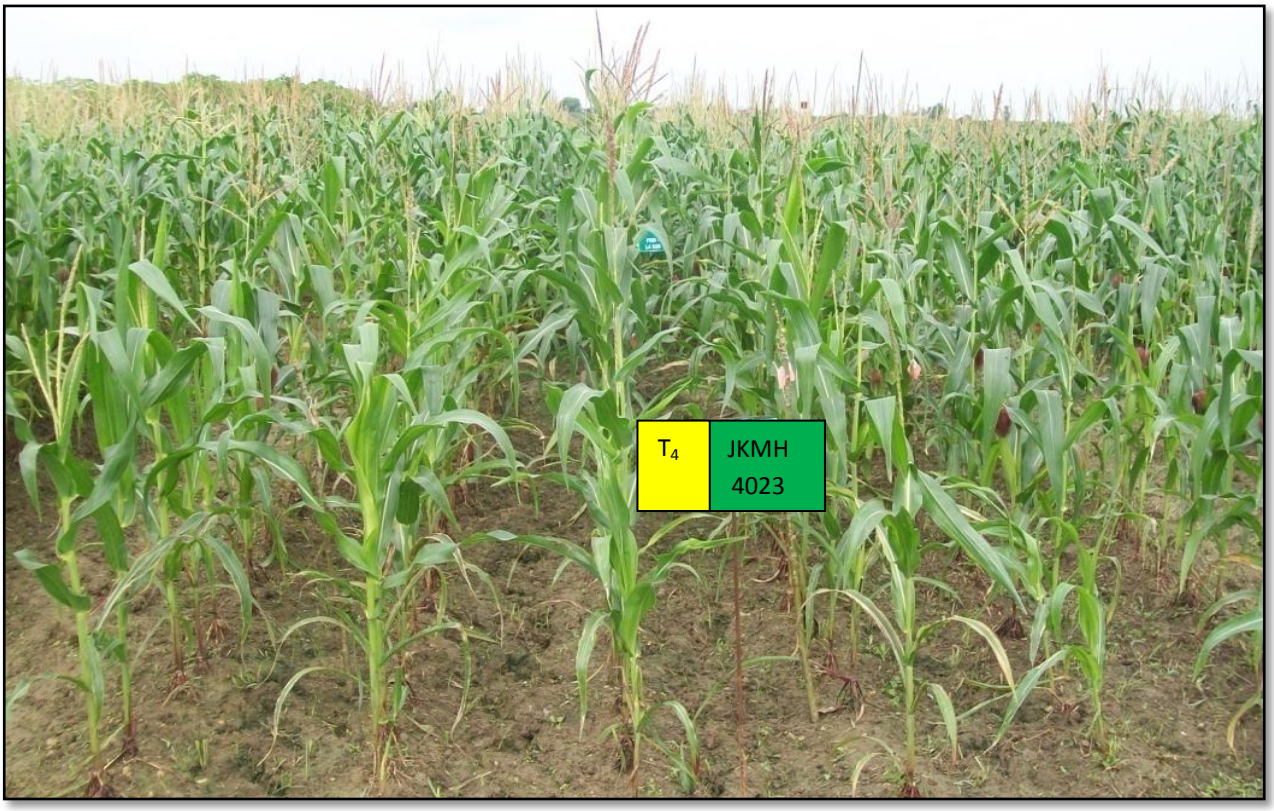
Walkley A and Black CA. 1934. An Experimentation for Degt-Jreff method for determination soil organic matter and proposal for modification of chromic acid titration method. Soil Sci. 37: 29-38.

Yakadri TR, Rao MLM. 2003. Variation in growth rates and seed yield in genotypes of maize (*Zea mays* L.). Agricultural Science Digest 23 (2): 104-106.


T1
JKMH
502

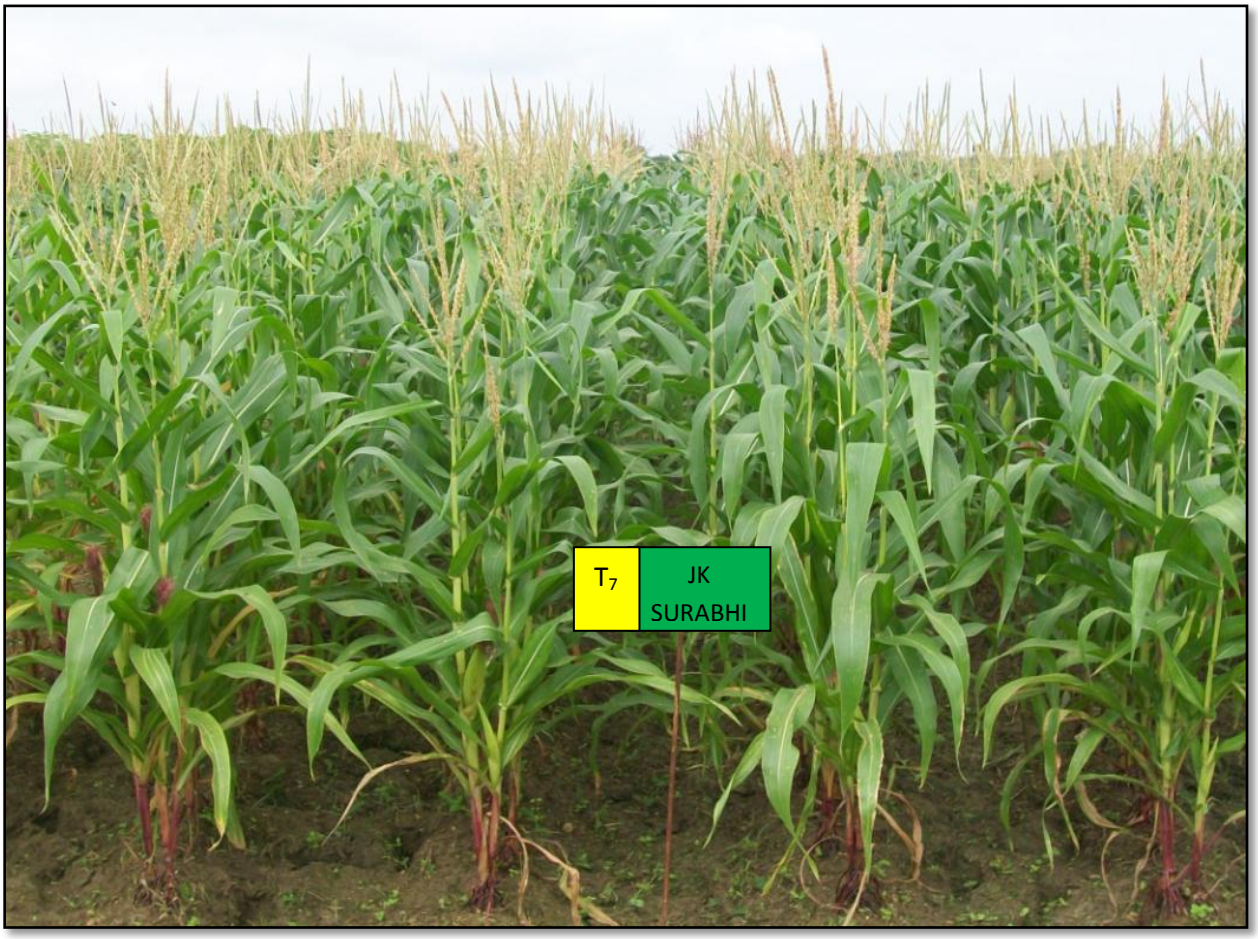

T2
JKMH
1701


T3
JKMH
4545


T4
JKMH
4023


T_5
JKMH 4025


T_6
JKMH 4029


T7
JK
SURABHI

APPENDIX - I

(A) Mean sum of square for growth parameters of maize hybrids

Sources of variation	d.f.	Plant populations		Growth parameters						
				Plant height (cm)				Leaves per plant		
		At 15 DAS	At maturity	30 DAS	60 DAS	90 DAS	At harvest	At 30 DAS	At 60 DAS	At 90 DAS
Replication	2	0.04	0.14	0.13	0.07	0.23	1.23	0.52	0.14	0.23
Treatment	7	0.01	0.25	7.07	721.75	662.73	716.23	0.66	1.27	3.15
Error	14	0.01	0.36	1.14	1.19	1.05	0.7	0.89	1.14	0.15

Contd…

Contd…

Sources of variation	d.f.	Growth parameters										
		Leaf area (cm²)			Dry matter production per plant (g)				SPAD value			
		At 30 DAS	At 60 DAS	At 90 DAS	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	Mean
Replication	2	18060.2	276.51	185.49	1.31	0.81	3.12	8.47	17.05	2.12	8.01	2.27
Treatment	7	145929	285825	786004	0.98	19.09	869.62	976.62	57.39	111.16	43.69	20.56
Error	14	45674.2	516.13	138.47	4.47	0.79	1.22	8.92	9.61	19.4	2.81	2.29

(B) Mean sum of square for physiological parameters of maize hybrids

Sources of variation	d.f	Leaf area index		Crop growth rate			Relative growth rate			Nate assimilation rate	
		60 DAS	At harvest	60 DAS	90 DAS	At harvest	60 DAS	90 DAS	At harvest	60 DAS	90 DAS
Replication	2	5.32	0.70	13.23	0.67	0.21	0.00005	0.000004	0.00001	10.23	0.57
Treatment	7	0.25	0.69	0.68	32.10	4.17	0.00028	0.000037	0.00004	0.12	1.86
Error	14	2.18	0.46	4.90	0.25	0.07	0.00001	0.000003	0.000003	3.55	0.57

APPENDIX-II

(A) Mean sum of square for different yield attributing characters and yield

Source of variation	d.f.	Rows/cob	Grains /row	Grains/ cob	Grain weight (g)	Cob length (cm)	Cob girth (cm)	Seed index	Grain yield (q/ha)	Stover yield (q/ha)	Shelling percentage	Harvest index
Replication	2	0.14	1.75	0.75	0.67	1.39	0.15	0.51	0.70	2.00	0.00	0.00
Treatment	6	4.00	20.96	2946.67	234.37	6.39	1.24	10.43	97.84	367.27	56.81	33.90
Error	12	0.06	0.91	0.29	0.23	0.46	1.19	0.22	0.26	0.76	0.00	0.33

(B) Mean sum of square for uptake of N, P, and K uptake

Source of variation	d.f.	Uptake of N (kg/ha)	Uptake of P (kg/ha)	Uptake of K (kg/ha)
Replication	2	19.07	6.28	26.02
Treatment	6	15128.91	1139.12	19469.46
Error	12	7.56	7.47	9.38

APPENDIX- III

Procedure for calculating the cost of cultivation on per hectare area basis

S.No.	Particulars	Input (/ha)	Cost /unit (Rs.)	Cost (Rs)
1.	**Field preparation**			
a.	Ploughing	2 pass	800	1600
b.	harrowing	2 pass	800	1600
c.	leveling	1pass	200	200
d.	Furrow and ridges	8 labour	150	1200
2.	**Seed and sowing**			
e.	Seed treatment with carbendazim and thiram		3g/kg	30
f.	Sowing charges	8 labour	150	1200
3	**Fertilizers**			
h.	Nitrogen	120 kg	13/kg	1560
i.	Phosphorous	60 kg	25/kg	1500
j.	Potash	40 kg	9/kg	360
k.	Application charges	2 labour	150	300
4	**Plant protections**			
l.	Weeding (2 times)	(20+20) labour	150	6000
m.	Insecticide (Chloropyriphos 50 EC)	1.5L		300
n.	Application charges	2 labour	150	300
o.	Watching	20 man days	150	3000
5.	**Harvesting and transport**	10 labour	150	1500
6.	**Shelling and winnowing**	20 man days	150	3000
7.	**Land revenue**	6 months	5000/year	2500
	Cost of cultivation			**26150**

APPENDIX- IV

Economic analysis of different treatments in maize

Treatment	Grain yield (q/ha)	Returns from grain Rs/ ha	Stover yield Kg/ha	Returns from stover Rs/ha	Gross monetary returns Rs/ha	Cost of treatments Rs/ha	Cost of treatments Rs/ha	Total cost of cultivation Rs/ha	Net monetary returns Rs/ha	B:C Ratio
JKMH 502	51.84	67392	152.98	15298	82690	26150	2700	28850	53840	2.86
JKMH 1701	55.32	71916	147.68	14768	86684	26150	2700	28850	57830	3.00
JKMH 4545	42.89	55757	138.15	13815	69572	26150	2700	28850	40722	2.41
JKMH 4023	56.14	72982	140.30	14030	87012	26150	2700	28850	58162	3.01
JKMH 4025	57.20	74360	130.89	13089	87449	26150	2700	28850	58599	3.03
JKMH 4029	58.33	75829	128.24	12824	88653	26150	2700	28850	59803	3.07
JK SURABHI	59.84	77792	120.68	12068	89860	26150	2700	28850	61010	3.11

ABSTRACT

Title of the thesis	**:**	**Relative performance of maize hybrid under rainfed conditions of Jabalpur**
Student Name	**:**	**Ms. Ankita Katare**
Address	**:**	D/O Shri Awadh Bihari Katare Dubey colony durga chowk khirhanai Katni, (Madhya Pradesh)
Advisor Name	**:**	**Dr. Girish Jha**
Address	**:**	Professor and Head of the Department Department of Agronomy Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur - 482004 (M.P.) Email. girishagcrewa@rediffmail.com Mo- 09425186360
Degree awarded	**:**	M.Sc. (Ag.) Agronomy
Year of award of Degree	**:**	2015
Major Subject	**:**	Agronomy
Total number of pages in the thesis	**:**	85
Number of words in the abstract	**:**	958

Dr. Girish Jha (Advisor)	**Dr. Girish Jha** (Professor & Head)	**Ms. Ankita Katare** (Student)

ABSTRACT

Blackgram is one of the important pulse crops in India. Intensive use of agro – chemicals that to fertilizers coupled with congenial edaphic and weather conditions during kharif season further aggravate the weed menace, resulting in lower yields of black gram, if weeds are not controlled in time with proper method. Hand weeding is widely used practice for eliminating the weeds, though it is costly and time consuming. Hence chemical weed control has become potent tool for curbing the weed menace since last two decades. Presently, imazethapyr is a very effective post emergence herbicide for controlling broad leaf weeds in kharif pulses including blackgram but its weed control efficacy has not been judged in combination with propaquizafop for wide spectrum weed control in different parts of the country including Jabalpur. An experiment was conducted at Product Testing Unit, Department of Agronomy, JNKVV, Jabalpur during *kharif* seasons of 2014 in order to test the efficacy of propaquizafop and imazethapyr mixture against weeds, yield and economics of black gram. The present experiment was carried out on clayey soil which was neutral in reaction, medium in organic carbon (0.65%), available nitrogen (363 kg/ha), phosphorus (17.20 kg/ha) and high in available potassium (335 kg/ha). The experimental field was having mixed weed flora comprising of grassy as well as broad leaved weeds. Nine treatments comprised of four rates of application of propaquizafop+ imazethapyr at 47+70,50+75,53+80 and 56+85 g/ha and alone application of propaquizafop (100 g/ha), imazethapyr (100 g/ha), pendimethalin (1500 g/ha) and hand weeding twice at 20 and 40 DAS including weedy check, were laid out in Randomized Block Design with three replications. All herbicide treatments were applied in 500 liters of water per hectare, using flat fan nozzle as per the treatments.

In the experimental field, *Echinochloa colona* (29.39%) and *Dinebra retroflexa* (24.30%) were the rampant weeds. However, other monocot weeds like *Cyperus iria* (18.19%) and dicot weeds like *Mullugo* pentaphylla (12.23%), Eclipta *alba* (7.58%) and *Alternanthera philoxeroides* (8.31%) were also present in less numbers in blackgram under weedy check plots. Weedy check plots receiving no weed control had maximum

weed density of weeds than herbicidal treatments including hand weeding twice. The weed menace was almost minimum under the hand weeding done at 20 and 40 DAS but it was increased at harvest due to emergence of weeds like *Cyprus irria* during later part of crop growth. Among the herbicidal treatments, activity of propaquizafop+imazethapyr mixture at the lowest dose (47+70 g/ha) as post-emergence was not well marked against most of the weeds but it was well marked when it was applied between 53+80 and 56+85 g/ha due to effective control of most of the associated weeds.

Weedy check had the highest weed biomass, which reduced significantly when weeds were controlled either chemically through herbicides or mechanically at 20 and 40 DAS through hand weeding. Among the herbicidal treatments, application of propaquizafop+imazethapyr mixture at 53+80 g/ha or higher rate 56+85 g/ha arrested the weed biomass production remarkably and proved superior to lower doses of mixture and alone application of imazethapyr (100 g/ha), propaquizafop (100 g/ha) and pendimethalin (1500 g/ha). The 99.04 per cent weed control efficiency was noted under hand weeding treatment at 30 DAA due to lowest weed biomass production and excelled to all the herbicidal treatments.

Plant population of blackgram was not affected due to weed control treatments. It was practically similar in all the treatments viz., post emergence application of propaquizafop+imazethapyr mixture at 47+70,50+75,53+80 and 56+85 g/ha and alone application of propaquizafop (100 g/ha), imazethapyr (100 g/ha) pendimethalin (1500 g/ha), hand weeding twice (20 and 40 DAS) including weedy plots at 30 DAS and harvest, indicating that these treatments did not adversely affect the germination and further growth of crop plants. Consequently, the plant population was almost similar under all treatments. Growth parametes like plant height, LAI, branches per plant, crop biomass, and effective nodules per plant were significantly superior in treated plots than weedy check. However, hand weeding treatment was having better yield attributing traits viz., pods per plant, seeds per pod and seed index (100 seed weight) to that of propaquizafop+imazethapyr mixture applied at 53+80 and 56+85 g/ha compared to alone application of imazethapyr (100 g/ha), propaquizafop (100 g/ha) and

pendimethalin (1500 g/h) including weedy check plots due to elimination of weeds during critical period of crop growth.

Yield attributing traits like pods/plant, seeds/pod, seed index, seed and haulm yields were significantly higher under all the plots receiving weed control measures than weedy check. Post emergence application of propaquizafop+imazethapyr mixture between 53+80 to 56+85 g/ha recorded higher values of pods per plant, seeds/pod, seed index and seed and haulm yields and proved significantly superior over lower rate of propaquizafop+imazethapyr mixture (47+70 and 50+75 g/ha) and alone application of propaquizafop (100 g/ha), imazethapyr (100 g/ha) and pendimethalin (1500 g/ha) but at par to hand weeding twice.

Hand weeding plots required the maximum investment (Rs 10500/ha) to control weeds while expenditure incurred under propaquizafop+imazethapyr at different rates (47+70,50+75,53+80 and 56+85 g/ha) including alone application of propaquizafop (100 g/ha), imazethapyr (100 g/ha) and pendimethalin (1500 g/ha) ranged between Rs 1050 to 2800/ha, indicating that control of weed through hand weedings was more expensive than the use of herbicides (propaquizafop and imazethapyr alone or in mixture) in black gram. Maximum gross monetary returns (Rs 83108/ha) was fetched under hand weeding twice (20 and 40 DAS) followed by combined application of propaquizafop+imazethapyr at 56+85 g/ha (Rs 80508/ha), 53+80 g/ha (Rs 78388/ha) and 50+75 g/ha (Rs 70690/ha). Though the gross return was maximum in hand weeded treatment among all the treatments, the net monetary returns and B:C ratio were the highest (Rs 61103/ha and 4.15) under combined application of propaquizafop+imazethapyr at 56+85 g/ha followed propaquizafop+imazethapyr mixture applied at 53+80 g/ha (Rs 59077 and 4.06) and these treatments were found more remunerative than hand weeding twice, propaquizafop+imazethapyr mixture at lower rates (47+70 and 50+75 g/ha) and alone application of imazethapyr (100 g/ha), propaquizafop (100 g/ha) and pendimethalin (1500 g/ha).

ABSTRACT

Hybrid maize under optimum crop production, protection and nutrient management can produce economically more yield as compared to commercial varieties. The present investigation entitled “Relative performance of newly developed maize hybrids for growth, yield attributing traits and yield in vertisol under Kymore plateau and Satpura hill zone” was conducted at the Product testing unit, Department of Agronomy College of Agriculture JNKVV, Jabalpur (M.P.) during *kharif* 2014.

.

The soil of experiment field was sandy clay loam in texture with the pH of 7.3. The soil was medium in available nitrogen (395 kg/ha), medium in available phosphorus (17.85 kg/ha), medium in available potassium content (301 kg/ha) and 1.50 percent carbon with 0.31 ds/m at 25^0C electrical conductivity. The total rainfall received during the crop season was 1289.9 mm. The mean minimum and maximum temperature varies between 14.4 ^{0}C to 44.8 ^{0}C respectively. The relative humidity of the tract is ranged between 33 to 92 percent in morning and 12 to 79 percent in evening.

The experiment consisted of 7 hybrids of maize (JKMH 502, JKMH 1701, JKMH 4545, JKMH 4023, JKMH 4025, JKMH 4029 and JK Surabhi) under rainfed condition and was laid out in a randomized block design with 3 replications. The gross and net plot sizes were 5.0 m X 3.6 m and 4.0 m X 2.4 m, respectively. The seeds of maize were sown and fertilizer was applied on 11 July 2014.

A number of maize (*Zea mays* L.) hybrids have been developed recently and are now available in Madhya Pradesh. These hybrids are suited to different agro-climatic conditions and available inputs like irrigation and fertilizer. In view of declining area and poor productivity of maize in M.P., choice of suitable variety after a good scope to enhance the

production potential of rainfed maize in M.P. Therefore, a study was carried out on these aspects.

The plant height (cm) recorded at 30, 60, 90 DAS and maturity was significantly influenced by different treatments under rainfed condition. Treatments T_1 JKMH 502 was found significantly superior to other treatments. AT 30DAS hybrid JKMH 502 found the highest plant height (15.76cm). At 60, 90 DAS and at maturity JKMH 1701 recorded the highest plant height, (168.42 cm) at 60 DAS, (180.06 cm) 90 DAS and at maturity (179.02 cm) stages which are superior to other treatments. The lower plant height was recorded in hybrid JKMH 4545 at all stages 11.80 cm at 30 DAS, 122.24 cm at 60 DAS, 137.80 cm at 90 DAS and 135.20 cm at maturity stages. JK Surabhi recorded significantly higher dry weight per plant over the rest of the treatments at different successive growth stages (30, 60, 90 DAS and maturity).

The hybrid JK Surabhi recorded significantly higher number of leaves per plant at all the successive growth stages (30, 60, and 90 DAS) and proved significantly superior to most of the treatments. The same result found in leaf area (m^2) the hybrid JK Surabhi resulted in significantly greater values than others.

Hybrids were differed significantly for all the growth analytical characters viz. Leaf area index (LAI), Crop growth rate (CGR), Relative growth rate (RGR), Net assimilation rate (NAR). The growth analytical characters LAI, NAR and CGR had better expression under hybrid JK Surabhi at different successive growth stages. Whereas for RGR the values varies with different days stages at initially 60 and 90 DAS the hybrid JK Surabhi shows higher RGR and at maturity the hybrid JKMH 1701 shows highest RGR.

Hybrids were differed significantly for the entire yield attributing characters viz. number of cobs per plant, grain rows per cob, grains per

row, cob weight (g), seed index etc. The yield attributing characters had better expression JK Surabhi under rainfed condition. This resulted in an increase in cob bareness and grains per cob which ultimately led towards an increase in economic yield. The higher cob length (16.23cm) was shown by JK Surabhi and maximum cob girth (15.01 cm) was found in case of hybrid JKMH 4545.

The treatment T_7 JK Surabhi recorded higher higher grain weight (91.06 g), higher number of rows per cob (12), highest number of grain per rows (23.01), total grains per cob (276.23), and higher 100 grain weight (33.33 g) respectively.

Hybrids were differed significantly for grain and stover yields. The significant highest grain yield of rainfed condition was recorded (59.84 q/ha) from hybrid JK Surabhi as compared to other hybrids. However, the second best treatment was recorded (58.33 q/ha) from T_6 (JKMH 4029) as compared to other treatments. The lowest grain yield was recorded 42.89 q/ha from hybrid JKMH 4545. The treatment T_1 recorded the higher stover yield (152.98 q/ha) than remaining treatments. T_7 recorded lowest stover yield (120.68 q/ha).

The shelling percentage was found significantly higher in case of Hybrid JK Surabhi (66.24%). The lowest shelling percentage was found in case of hybrid JKMH 4545 (56.38%). The harvest index of maize was also recorded significantly higher due to hybrids. The highest harvest index was observed in JK Surabhi (33.14%). Lowest harvest index was observed in JKMH 4545 (23.69%).

Hybrids were differed significantly for total uptake of major nutrients (NPK). The significant highest total N, P and K uptake (both in grain and stover) varies with hybrids. The hybrids JK Surabhi was recorded highest total N uptake (275.85 kg/ha), total uptake of P (75.79 kg/ha) and total K uptake (287.86 kg/ha) as compare to other treatments.

The GMR was maximum (Rs. 89860/ha) with T_7 closely followed by T_6 (Rs. 88653/ha). The GMR was remarkably minimum (Rs. 69572/ha) with T_3 among all treatments.

Treatment T_7 JK Surabhi recorded maximum NMR (Rs. 61010/ha) among all treatments. The next best treatment was T_6 with NMR of Rs. 59803/ha. T_3 (Rs. 40722/ha) fetched the minimum NMR among all treatments.

CURRICULUM VITAE

Name of the author- Miss Ankita Katare

Place- Katni

Date of Birth- 3rd September 1991

The author of this thesis Miss Ankita Katare, D/o Mr. Awadh Bihari Katare and Mrs. Rita Katare was born on 3rd September 1991 at Katni (Madhya Pradesh). She has joined the following institutions and successfully completed the degree of M.Sc. (Ag.) during the year 2014-15 with 8.00 OGPA with 10 point scale.

S. No.	Institutions
1	JNKVV, Jabalpur 2015
2	JNKVV, Jabalpur 2013
3	St. Paul's H.S School Katni (Madhya Pradesh)
4	St. Paul's H.S School Katni (Madhya Pradesh)

She has got the following degrees,

S. No.	Degrees granted	University/Board	Year
1	M.Sc. (Ag.)	JNKVV, Jabalpur	2015
2	B.Sc. (Ag.)	JNKVV, Jabalpur	2013
3	12th	St. Paul's H.S School Katni (Madhya Pradesh)	2009
4	10th	St. Paul's H.S School Katni (Madhya Pradesh)	2007

She has following scientific interests-

Scientific interests

a. Agronomy
b. Research Works on "Hi-tech agriculture" including weed Science

For the partial fulfilment of the master's degree programme she was allotted a research problem on "Relative performance of maize hybrid under rainfed conditions of Jabalpur" which was successfully conducted by her and being submitted in the form of the thesis.