

**“IMPACT OF GROWTH SUBSTANCE BRASSINOLIDE
ON MORPHO-PHYSIOLOGICAL AND YIELD
ATTRIBUTES OF RICE (*Oryza sativa* L.) GENOTYPES”**

M.Sc. (Ag.) THESIS

by

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**DEPARTMENT OF PLANT PHYSIOLOGY
COLLEGE OF AGRICULTURE
INDIRA GANDHI KRISHI VISHWAVIDYALAYA
RAIPUR (C.G.)**

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**“IMPACT OF GROWTH SUBSTANCE BRASSINOLIDE
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THESIS

Submitted to the

**INDIRA GANDHI KRISHI VISHWAVIDYALAYA
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by

ANITA CHOUDHARY

**IN PARTIAL FULFILMENT OF THE
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CERTIFICATE-I

This is to certify that the thesis entitled “**Impact of growth substance brassinolide on morpho-physiological and yield attributes of rice (*Oryza sativa* L.) genotypes**” submitted in partial fulfilment of the requirements for the degree of “**Master of Science in Agriculture**” of the Indira Gandhi Krishi Vishwavidyalaya, Raipur, is a record of the bonafide research work carried out by **ANITA CHOUDHARY** under my guidance and supervision. The subject of the thesis has been approved by Student's Advisory Committee and the Director of Instructions.

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 have been duly acknowledged by her.

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CERTIFICATE – II

This is to certify that the thesis entitled “**Impact of growth substance brassinolide on morpho-physiological and yield attributes of rice (*Oryza sativa* L.) genotypes**” submitted by **ANITA CHOUDHARY** to the Indira Gandhi Krishi Vishwavidyalaya, Raipur in partial fulfilment of the requirements for the degree of **M. Sc. (Ag.)** in the **Department of Plant Physiology** has been approved by the external examiner and Student's Advisory Committee after oral examination.

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CHAPTER-I

INTRODUCTION

Man has made tools for more than a million years, but his crop plants have evolved under the influence of his power of observation, selection and imagination. Some of the crop like “Rice” would no longer survive without human investigation. Crop and man have evolved together in a kind of symbiosis. As Darlington (1969) has put it “In the silent millennia during the expansion of agriculture men themselves transformed by the new relation with plant which they themselves were in the process of stability”.

Rice (*Oryza sativa* L.) is one of the important staple cereal crops of the world. Presently rice is cultivated globally in 154 million hectare with annual production of 600 million tonnes and average productivity of 3.9 tonnes/ha. In Asia, 90 per cent of world rice is grown and consumed and about 2.8 million people derive 35-60 per cent of the total intake from rice. Rice contributes around 45 per cent of India’s cereal production and is the main staple food for over 60 percent of the population in the country. In India rice is cultivated in an area of 43.7 million hectare with a total production of 137.3 million tonnes. (Viraktamath *et al.* 2007).

The total geographical area of Chhattisgarh is 137.3 million hectare. Thus, small state is rewarded as “Rice bowl of India” has got 3.7 million hectare area under rice cultivation with production of 4.68 million tonnes (Anonymous *et al.* 2005). To meet the demands of increasing population the present production level of around 89 millions tons, need to be increased up to 88 million tons by the year 2020. This increase in production has to be achieved in the backdrop of declining and deteriorating resource base such as land, water labour and other inputs and without adversely affecting the quality of environment. (Ilyas *et at* 2007). Crop yield is liked with tillering behavior, leaf area index and photosynthetic efficiency during vegetative stage. The appropriate relationship between sources sink and their capacity is essential to impact on yield improvement especially in rice (Song *et al.*1990).

Plant growth regulators are other than nutrient usually an organic compound which synthesized is one tissue and migrates to another tissue of the plant where in very minute quantity affect the growth (Philips 1971). It can improve the vegetative growth and used to have a proper balance between source

and sink for increasing crop yield. Plant growth regulators are known to affect growth, assimilate, translocation, flowering and ion transport (Arteca 1997). Rice varieties with high yield potential can be developed by increasing the number of grain per area, by increasing the grain weight or by a combination of both and plant growth regulators have such unique features to enhancing the yield. (Ebenezer *et al.* 2000).

Brassinolide is a new group of plant hormone with growth promoting activity, when applied exogenously at sub micromolar concentration. It elicit several physiological and biochemical response in various test systems ranging from single cell to whole plants (Mandava *et al.* 1988). It is considered as phytohormone with pleiotropic effect, as they influence varied physiological processes like growth, germination, abscission, maturation, flowering and senescence (Sasse *et al* 1999). The exogenously applied brassinolide has the ability to improve the crop yield of rice (Krishnan *et al.* 1999). Brassinolide induced plant growth is associated with induced plant growth with increased metabolic process like photosynthesis (Sairam 1994).

The major limitation is that the growth regulators are effective only at specific concentration. The times of application and dose at different stages are also crucial for getting beneficial effect in yield of rice.

In view of the above facts, present investigation entitled “Impact of growth substance brassinolide on morpho-physiological and yield attributes of rice (*Oryza sativa* L.) genotypes” was carried out with the following objectives:

1. To study the effect of brassinolide on morpho-physiological characters of rice genotypes.
2. To examine the impact of brassinolide on yield attributes of rice genotypes.
3. To analyse the biochemical parameter of rice genotypes influenced by brassinolide.

CHAPTER-II

REVIEW OF LITERATURE

The crop yield is a function of various production technologies which play a vital role in boosting up the yield. The growth of plant is very much regulated by certain chemical substances that are synthesized by plant in very small quantities. Unlike the genes and most of the enzymes, these substances are synthesized in one tissue or organ of the plant and are then transported to other sites where they produce specific effects on growth and development. They are referred as phytohormones or plant growth regulators.

A brief review of research work done in Chhattisgarh, India and abroad regarding *Kharif* rice and other crops have been presented in this chapter under the following sub headings:

- 2.1** Effect of brassinolide on morphological and growth behaviour of rice and other crops.
- 2.2** Effect of brassinolide on physiological behaviour of rice and other crops.
- 2.3** Effect of brassinolide on biochemical behaviour of rice and other crops.
- 2.4** Effect of brassinolide on yield attributes of rice and other crops.

2.1 Effect of brassinolide on morphological and growth behaviour of rice and other crops

Lim *et al.* (1985) reported that the application of brassinolide at 0.1, 0.5 and 1 ppm increased the fresh weight, dry weight and the number of fruit in tomato.

Yokota *et al.* (1986) studied that brassinolide increased leaf yield in tobacco.

Meudt and Fuller *et al.* (1987) reported that brassinolide and 11 biologically active isomers of brassinolide isolated from higher plants and had given the three bioassay technique in rice and found that brassinolide affected the specific target tissue which was sensitive to IAA. They also suggested that brassinolide regulates plant tissue sensitive to auxin and to geotropic stimulation.

Zhou *et al.* (1987) reported that brassinolide increased embryonic root length, seedling dry weight and amylase activity in rice.

Delauney *et al.* (1991) reported that brassinosteroids enhanced the proline contents. It is well known when plants are challenged with salinity stress, there is accumulation of free proline and it plays

an important role in osmoregulation and increases tolerance in rice.

Ikekawa *et al.* (1991) observed that epibrassinolide increased leaf yield in tobacco.

Luo *et al.* (1992) reported that brassinolide treated plants generally showed higher growth rates, tolerance to chilling, CO₂ assimilation rate and improved translocation and partitioning of photosynthates. Brassinolide also increased germination rate, pollen tube elongation in rice, wheat, maize, cotton, tomato and soyabean.

Yokota *et al.* (1992) studied that transport and metabolism of 34 brassinolide in root and leaves of rice cv. Koshihikari. They reported that after supplying of their content to the roots for 6 hours these brassinolide incorporated in both root and shoot of the crop.

Amzallag *et al.* (1997) found that brassinolide enhanced levels of nucleic acid and soluble protein in rice.

Hebbalkar *et al.* (1997) worked on effect of homobrassinolide in rice and influenced the shape, size and growth of the plant and enhanced the plant height, quality and yield of crop.

Ramraj *et al.* (1997) reported that spray of homobrassinolide increased number of leaves, leaf area index (LAI) and dry matter production in cotton.

Vardhini and Rao (1999) reported that foliar application of brassinolide increased nodulation, nitrogen fixation in groundnut.

Asami *et al.* (2000) inhibitor studied on inhibitor employing brassinazole, a specific inhibitor of brassinolide in plant, and found that strengthened the view brassinosteroids are essential for growth and development in cereals.

Fujii and Saka *et al.* (2001) observed that the leaf spraying of brassinolide on rice at seedling stage the 4th leaf increased the plant height and fresh weight of tops and roots even at low temperature. The combination of brassinolide and IAA synergistically promoted cell elongation at a low temperature.

Anuradha *et al.* (2002) reported that brassinolide had to reverse the inhibitory effect on germination and seedling growth. The activation of seedling growth by brassinolide under salinity stress was associated with enhanced level of nucleic acids, soluble protein and free proline in rice.

Fujii and Saka *et al.* (2003) found that the application of brassinosteroids improved cell division, expansion and differentiation including source sink relation and other endogenous interactions in the rice

crops.

Nakashita *et al.* (2003) studied that brassinolide considered to be the most important brassinosteroids. It plays pivotal role in the hormonal regulation of plant growth and induced disease resistance in the plant. The potentialities of brassinolide activity on stress responding system analyzed and found its ability to induced disease resistance in tobacco and rice plants. Brassinolide also induced resistance in rice blast and bacterial blight.

Prakash *et al.* (2006) found that exogenous application of brassinolide, might have helped in better rooting and enhanced uptake of more nutrients which leading to increased morphological parameter like plant height, number of leaves and number of branches, and specific leaf weight which contributing to higher total dry matter production in rice.

Vidya *et al.* (2006) observed that brassinosteroids are a new group of plant growth substance with significant growth promoting activity in rice.

2.2 Effect of brassinolide on physiological behaviour of rice and other crops

Lim *et al.* (1987) reported that application of brassinolide at 0.1 ppm increased protein content and photosynthesis rate in rice.

Chang *et al.* (1988) found that homobrassinolide significantly improved germination and α -amylase activity in seedling of rice and wheat.

Dong *et al.* (1989) reported that treatment of brassinolide increased germination, α -amylase activity and cold resistance in rice seedling.

Kim and Sa (1989) studied that application of brassinolide very effective at very low concentration. They showed spray of 1 ppm brassinolide increased number of root/plant and most effective to increased dry weight and root elongation after transplanting in rice.

Iwahori *et al.* (1990) studied that application of homobrassinolide delayed leaf senescence in mustard.

Kuleava *et al.* (1991) studied that brassinosteroids enhanced photosynthetic rate and nitrate reductase activity in wheat.

Petzold *et al.* (1992) reported that treatment of brassinolide might to have resulted an increased in assimilate transport from source to sink and their ultimate conversion into final reserved food in

groundnut.

Sairam *et al.* (1994) reported that brassinolide induced plant growth and was associated with increased metabolic activities like photosynthesis in groundnut.

Xu *et al.* (1994) reported that brassinolide reduced abscission of young flowers and early maturation in grapes.

Arteca *et al.* (1997) studied that brassinosteroids affected growth, assimilate translocation, flowering and ion transport in mustard.

Rajasekaran *et al.* (1999) studied that brassinosteroids enhanced photosynthesis and growth in jackpine.

Sasse *et al.* (1999) found that brassinosteroids are considered as plant hormone with pleiotropic effect as they influence wide array of developmental processes such as growth, seed germination, rhizogenesis, flowering, senescence, abscission and maturation in cereals.

Hayat *et al.* (2001) reported that application of 28-homobrassinolide accelerated net photosynthesis rate in wheat.

Rao *et al.* (2002) reported that brassinosteroids can improved the resistance of the plants against environment stresses, and delay senescence which ultimate have impact on yield improvement of rice, maize, and tomato.

Pullman *et al.* (2003) studied that somatic embryogenesis, the most promising technology for the large scale production of high value coniferous trees from advanced breeding and genetic engineering programs, is expected to play an important role in increasing productivity, sustainability, and the uniformity of U.S. forest.

Prakash *et al.* (2006) studied that application of brassinolide enhanced various physiological and biochemical processes ultimately leading to increased like crop growth rate (CGR) and relative growth rate (RGR) in rice crops.

2.3 Effect of brassinolide on biochemical behaviour of rice and other crops

Kalinch *et al.* (1985) found that application of brassinolide at sub micromolar concentration increased protein synthesis in groundnut.

Mandava *et al.* (1987) have also reported that application of brassinosteroids increased nucleic

acid and protein synthesis in wheat.

Nakajima *et al.* (1996) studied that epibrassinolide stimulated growth of Chinese cabbage mesophyll protoplast was associated with enhanced protein levels.

Sairam *et al.* (1996) reported that application of homobrassinolide as a seed treatment resulted in increased germination percentage, amylase activity and total sugar content in rice and wheat.

Vidya *et al.* (1997) reported that 28-homobrassinolide significantly increased the growth and yield of the plant. The growth promotion by homobrassinolide was associated with enhanced level of DNA, soluble protein and various carbohydrate fractions in groundnut.

Vardhini *et al.* (1998) studied that spraying of brassinosteroids improved total sugar and nitrogenase activity in groundnut.

Khripach *et al.* (2000) found that potentially of brassinosteroids improved productivity and growth regulation by influencing the nucleic acid and protein synthesis in rice and tomato.

Maibangsa *et al.* (2000) investigated that brassinolide increased the accumulation of chlorophyll content and increased biochemical efficiency with increased assimilation resulted in increased number of spikelets and reduction in spikelet sterility which enhanced yield in rice.

Fujii and Saka (2001) reported that rice plants exposed to a low temperature at the maturity stage the effect of brassinolide on the distribution aspects of carbohydrates in upper organs including the panicle of the rice plant. They further emphasized that brassinolide increased starch, starch content in leaf sheaths, culms and hulled grain in both temperature conditions. They also observed treatment increased the 1000 grain weight and the percentage of ripened grains in the rice plant.

Prakash *et al.* (2002) studied that foliar spray of brassinosteroids at different concentration (0.25, 0.50 and 1.00 mg l⁻¹) on 25, 30, 35 and 50 DAS on groundnut. The biochemical parameter like chlorophyll, soluble protein, sugar and nitrogenase activity were increased at 1.00 mg l⁻¹ concentration in groundnut.

2.4 Effect of brassinolide on yield attributes of rice and other crops

Braun *et al.* (1984) studied that brassinolide increased yield in of wheat crops.

Kumura *et al.* (1989) reported that application of brassinolide increased yield in rice and wheat.

Nakaseko *et al.* (1989) reported that epibrassinolide increased growth and yield in soybean.

Fujii *et al.* (1991) found that treatment of homobrassinolide increased yield under irrigated and stressed condition. The seed yield was primarily higher due to increased in number per ear, grain weight and harvest index in groundnut.

Herai *et al.* (1991) reported that brassinolide enhanced osmoregulation and grain yield in rice.

Ikekawa *et al.* (1991) reported that epibrassinolide increased growth and yield in maize.

Schilling *et al.* (1991) reported that the seeds were treated with homobrassinolide to improved seedling growth for the long term effect the number of ear per plant, grain per ear, grain weight and harvest index increased in wheat.

Sairam *et al.* (1994) found that homobrassinolide increased both growth and yield parameters in wheat.

Krishnan *et al.* (1996) found that brassinolide increased grain yield in rice.

Ramraj *et al.* (1997) reported that foliar application of brassinolide increased grain yield in wheat, rice, mustard, pod yield in groundnut and tuber yield in potato.

Vardhini and Rao (1998) observed that the exogenous application of brassinolide increased the growth and yield of groundnut.

Krishnan *et al.* (1999) studied that the ability of exogenously applied brassinosteroids to improved crop yield of rice.

Thirthalingappa *et al.* (1999) found that brassinolide increased plant height, number of tillers plant⁻¹, productive tiller plant⁻¹, panicle length, number of filled spikelets panicle⁻¹, in rice.

Jin *et al.* (1999) reported that natural brassinolide is a new growth regulator which increased vigour and yield in of early rice.

Yang *et al.* (1999) reported that brassinolide increased the numbers of grains per panicle and was ultimately increased yield in rice.

Ebenezer *et al.* (2000) studied that brassinolide promoted growth of palea and lemma. The application of brassinolide at panicle initiation stage was increasing the number of grain per area and grain weight in rice crop. Brassinolide have also clarified certain unique features of the spikelets of rice grains and have identified strategies required to enhance the weight of rice grains.

Vardhini and Rao (2001) studied that brassinolide increased growth and yield in tomato.

Saka and Fujii (2001) studied the effect of brassinolide application at flowering stages and were observed that brassinolide promoted panicle ripening in rice plant.

CHAPTER-III

MATERIALS AND METHODS

The present study entitled “Impact of growth substance brassinolide on morpho-physiological and yield attributes of rice (*Oryza sativa* L.) genotypes” was carried out during *kharif* season of the year 2007-08.

The details of experimental materials used and techniques during the course of investigation are briefly presented in this chapter:

3.1 Experimental site

The experiment was conducted during *kharif season* 2007-08 at Instructional Farm, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.).

3.2 Geographical situation

Raipur is situated in the central part of the Chhattisgarh and lies at 21⁰16' N latitude and 81⁰36 E' longitude with an altitude of 298.6 m above the mean sea level.

3.3 Climate

Climatologically, Raipur is classified as slightly moist hot zone. The source of rainfall is South-Western monsoon. The region receives an average annual rainfall of 1325 mm (based on 80 years mean), mostly concentrated during the period from June to September. May and December months are the hottest and coolest months, respectively. The weekly maximum temperature rises up to 46⁰C during summer and minimum temperature reaches as low as to 6⁰C. The relative humidity is high from June to

October and wind velocity is high from May to August with its peak in June-July months.

3.4 Weather condition during crop growth period

The average weather data recorded during the crop growth period are given in appendix-1 and depicted through (Fig. 3.1).

The metrological observation recorded during the crop growth period showed that the (average) maximum temperature varied between 32.1⁰C whereas minimum temperature ranged between 11.6⁰C. The maximum and minimum relative humidity varied between per day sunshine hours varied between hours per day.

3.5 Experimental details

The experiment was laid out in factorial randomized block design with two replications. Two factors are taken and their combination is made as treatment. The treatments were allotted to different plots by using random method (Gomez and Gomez, 1984).

The details of the experiment of treatments are given in Table 3.1 and plan of lay out is depicted in Fig. (3.2).

Table 3.1: Experimental details

Particulars	Details
Design	Factorial experiment in RBD layout.
No. of Treatments	Twenty four (24)
Replication	Two (2)
Total no. of plots	Forty eight (48)
Plot size	3 × 2.75 m ²
Spacing between replication	1.50 m.
Plot to plot spacing	50 cm
Plant to plant spacing	20 cm
Row to row spacing	15 cm
Fertilizer dose (NPK)	100: 80: 60

3.6

3.7 Test crops:

S. No.	Early duration genotypes	S. No.	Mid duration genotypes	S. No.	Late duration genotypes
1	R-1037-649-1-1	1	Indira Sugandhit Dhan	1	Safri-17
2	Danteshwari	2	R-1182-167-2-157-1	2	Dubraj
3	R-979-1528-2-1	3	R-548-89-6	3	R-1249-1196-2-1
4	Vasumati	4	R-1072-360-1	4	R-1060-1674-1-1

3.7 Treatment details

T₁ - Control

T₂ - Brassinolide

3.8 Determination of stages

The phasic development of plant was recorded regularly after developing nursery sowing to maturity.

3.8.1 Tillering

The tillering stage was determined when the emergence of second tiller was initiated on second node.

3.8.2 Panicle initiation (PI stage)

For recording PI stage, plants from border were uprooted and main culm was dissected from the base and stems by magnifying lens. When there was a silky appearance present that was considered as PI stage.

3.8.3 Flowering stage

When stamens of spikelets came out and yellowish white structure was seen on spikelets of earlier appeared tiller it was considered as flowering stages.

3.8.4 Grain fillings stage

It was observed on the basis of visual score when early 50 per cent flowers were appeared in experimental plot. It was considered as 50 per cent flowering.

3.8.5 Maturity stage

The maturity was assumed as 30-40 days after 50 per cent flowering and crop harvested.

3.9 Brassinolide application

Brassinolide is a growth promoter and marked by Godrej Company with the trade name of Godrej Double. A knapsack hand sprayer of fifteen litre capacity, which was thoroughly washed before the spray, sprayed each plot carefully and uniformly.

The foliar spray was done at two stages of the crop growth *viz.* 1st spray 30 days after sowing and 2nd spray after flowering *i.e.*, 60 days after sowing.

3.9.1 Raising of nursery

Well-pulverized raised nursery beds of 10m x 1.0m dimension were prepared. The irrigation and drainage was provided between two beds. The fertilizer application 400 g to each bed at the time of nursery bed preparation. Seeds were sown in rows on the raised bed by hand drilling. The seeds were thoroughly covered with soil and frequent irrigation was given until the seedlings were transplanted.

3.9.2 Seed treatment

Seeds were treated with 10 per cent salt solution in order to select the healthy seeds. The seeds settled at the bottom were used for nursery raising. In order to prevent

the crop from seed and soil borne disease the seeds were treated with Bavistin @ 2.5 g kg⁻¹ Seed before sowing in nursery.

3.9.3 Fertilizer application

The fertilizers were applied as per the requirement of crop 100:80:60 kg ha⁻¹ N: P: K was applied in the form of urea, DAP and MOP, respectively. The half dose of N was applied as basal dressing and the rest half N was applied in two split dose at 30 and 50 days after transplanting. The whole amount of phosphorus and potash was applied as basal during transplanting.

3.9.4 Field preparation

The field was prepared by ploughing and cross ploughing with the tractor drawn cultivator. The field was puddled by tractor drawn puddler in presence of 8-10 cm standing water and was levelled by planker.

3.9.5 Transplanting

The 25 days aged seedlings were transplanted at spacing 20×15 cm in the field. The transplanting was done on 28 July 2007. The seedlings were planted in each hill.

3.9.6 Weed management

The crop was kept free throughout its growth period for avoiding crop weed competition. The hand weeding was during the crop growth.

3.9.7 Water management

After transplanting the soil was kept saturated until planted seedlings get established and 5+2 cm. standing water level was maintained until grain hardening stage (10 days prior to harvesting).

3.9.8 Harvesting and threshing

The harvesting was done on 25th November with the help of sickles by manual labourers. Harvested produce was left on the plot itself for sun drying for three to four days. After sun drying the produce was weighted plot wise. Threshing was done by manual labourers with the help of wooden sticks. The material threshed from each plot was kept separately and grains were separated from the chaff and straw by winnowing with help of “*supa*” and clean grains were weighed.

3.10 Observations recorded

The observations were classified as morphological, physiological, biochemical and yield parameters. The techniques followed for various observations are described below.

3.10.1 Morphological parameters

The three plants from each plot were taken randomly from the net plot and were tagged. The randomly selected plants were used for recording observations on various plant characters.

3.10.2 Plant height (cm)

Height of randomly selected tagged plant was recorded in each plot at 30 days till maturity. The height was recorded in centimeter from ground level to the uppermost leaf tip. At maturity, it was measured up to the tip of the panicle.

3.10.3 Number of tillers plant⁻¹

The total number of tillers was counted in each treatment genotypes and its average value was used for analysis. The numbers of productive and un-productive tillers were given on the basis of average value of three plants.

3.10.4 Number of leaves plant⁻¹

The numbers of full open leaves considered as green leaves were counted in uprooted plant at different growth period.

3.10.5 Flag leaf area (cm²)

Upper most fully expanded leaf on the mother tiller was selected for the estimation of flag leaf area at flowering stage. The length maximum and width of flag leaf were recorded at 50 percent flowering stage and 15 days after flowering. A factor of 0.75 was used to calculate the flag leaf area.

$$\text{Flag leaf area} = \text{Length} \times \text{Width} \times K \text{ (factor} = 0.75\text{)}$$

3.10.6 Dry weight of plant (g)

The crop dry weight was recorded at different growth stages. The plant from net plot was taken randomly. The samples were initially air-dried followed by drying in an oven at 60⁰C for 48-72 hours to obtain constant weight. After drying the samples were weighed and dry matter accumulation per plant was recorded.

3.11 Physiological parameters

Methods of analyzing growth through plant sampling techniques. By this methods the plant are observed periodically for their height, flowering time and also sampled at different intervals when the different parts such as stem, leaf, seed etc. are separated, weighed and measured. From these the physiological parameters such as crop growth rate, relative growth rate were calculated and these are further analyzed in terms of contributing component parameters like leaf area index.

3.11.1 Leaf area index (LAI)

It is the leaf area (A) per unit of ground area (P), (Watson 1947).

$$\text{LAI} = \frac{A}{P} \times K$$

The value of K varies with the shape of the leaf which in turn is affected by the variety nutritional status and growth stage of leaf. However, the value 0.75 can be used for all stages of growth except the seedling stage and maturity for which value 0.67 should be used (Gomez, 1972).

3.11.2 Crop growth rate (CGR)

The average daily increment of shoot biomass (W_1 and W_2) per unit growth area (P) per unit time interval (t_1 and t_2) provided the rate of dry matter production of the crop stands (Potter and Jones, 1977).

$$\text{CGR} = \frac{W_2 - W_1}{P (t_2 - t_1)} \quad (\text{g}^{-1} \text{m}^{-2} \text{day}^{-1})$$

Where,

W_2 and W_1 are the total dry weight of plant at the time t_2 and t_1 respectively and P is the ground area.

3.11.3 Relative growth rate (RGR)

An index of amount of growing material per unit dry weight of plant per unit time (Leopold and Kriedmann, 1975).

$$\text{RGR} = \frac{\text{Ln } W_2 - \text{Ln } W_1}{t_2 - t_1} \quad (\text{g}^{-1} \text{g}^{-1} \text{day}^{-1})$$

Where,

$\text{Ln } W_2$ and $\text{Ln } W_1$ are the natural logarithm of total dry weight of plant at the time t_2 and t_1 .

3.11.4 Net Assimilation Rate (NAR)

NAR indirectly indicates the rate of net photosynthesis. It is expressed as g of

dry matter produced per cm² of leaf area in a day for calculating NAR, leaf area of individual plant has to be used (Leopold and Kriedmann, 1975).

$$\text{NAR} = \frac{W_2 - W_1 (\ln L_2 - \ln L_1)}{(t_2 - t_1) (L_2 - L_1)} \quad (\text{g}^{-1} \text{cm}^{-2} \text{day}^{-1})$$

Where,

W_1 = Total dry weight of plant at time t_1

W_2 = Total dry weight of plant at time t_2

$t_2 - t_1$ = Time interval in days

$\ln l_1$ = natural log of leaf area at t_1 time.

$\ln l_2$ = natural log of leaf area at t_2 time.

3.12 Biochemical Parameters

3.12.1 Chlorophyll Content (SPAD)

Chlorophyll content was measured as spade unit from the electronic instrument or device called chlorophyll meter. The chlorophyll was measured in the rainfed and irrigated condition by keeping the healthier leaf in the meter. The readings were taken between 12 to 2 pm of sunshine hours.

3.12.2 Carbohydrate content (%)

Material required (2.5 N HCl, Anthrone reagent, standard glucose stock, working standard). Pooled dry sample from all the replications were chopped and powdered in a willy grinding machine with 60 mesh sieve and analyzed for carbohydrate. Weigh 100 mg of the sample into a boiling tube, hydrolyse by keeping it in a boiling bath for three hours with 5 ml of 2.5 N HCl and cool it to room temperature. Neutralize it with sodium carbonate until the effervescence ceases, make up the volume to 100 ml and centrifuge, collect the supernatant and take 0.5 and 1 ml aliquots for

analysis then prepare the standard by taking 0, 0.2, 0.4, 0.6, 0.8 and 1 ml of the standard 0 serves as blank. Make the volume to 1 ml in all the tubes including the sample tubes by adding distilled water then add 4 ml of anthrone reagent, heat for eight minutes in boiling water bath, cool rapidly and read the green to dark green colour at 630 nm. Draw a standard curve by plotting graded concentration of the standard on the x-axis versus absorbance on (Hedge and Hofreiter, 1962).

Calculation

$$\text{Carbohydrate percent in 100 mg of the sample} = \frac{\text{mg of glucose}}{\text{Volume of test sample}} \times 100$$

3.13 Yield parameters

3.13.1 Number of productive tillers plant⁻¹

There plant sample from each plot were taken at plant and were counted productive tiller and unproductive tiller and were averaged.

3.13.2 Panicle length (cm)

The length of panicle was measured with the help of scale from all the panicles. It was measured from the neck node to the tip of the apical grain, after this average length of panicle was determined.

3.13.3 Panicle weight (g)

The panicles selected for measuring length were weighed and then mean value was worked out.

3.13.4 Number of filled grains

Numbers of filled grains were counted on the main tiller panicle.

3.13.5 Number of unfilled grains

Total number of filled grain per panicle was counted and percent of unfilled grains were calculated as follows:

$$\text{Unfilled grain (\%)} = \frac{\text{Number of unfilled grains}}{\text{Total number of grains}} \times 100$$

3.13.6 Grain yield plot⁻¹

Grain yield of the genotypes lines were noted down after threshing, winnowing and drying. Grain yield then calculated in quintal hectare⁻¹ with appropriate multiplication factor.

3.13.7 Harvest index (HI, %)

The ratio of economic product (seed) to the total above ground biomass at harvest (Synder and Carlson, 1984) was calculated by following formula

$$\text{H.I.} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Where,

Economical yield = grain yield

Biological yield = grain yield + straw yield (above ground biomass)

3.14 Statistical analysis

Experimental data were analyzed statistically, adopting the technique of variance (ANOVA) for a factorial randomized block design. The level of significance of the treatment mean square at 5 per cent probability was tested with 'F' test value. Using the significant differences of the treatment means (Gomez and Gomez, 1984).

CHAPTER-IV

RESULTS AND DISCUSSIONS

The present investigation entitled “Impact of growth substance brassinolide on morpho-physiological and yield attributes of rice (*Oryza sativa* L.) genotypes” was conducted during *kharif* season of the year 2007. With a view to study the efficacy of foliar application of brassinolide and its impact on morho-physiological and yield potential in rice genotypes. The experimental findings computed on the basis of recorded observation and statistical analysis. It has been presented in the appropriate form of table and figures in this chapter.

4.1 Morpho-physiological parameters

4.1.1 Plant height (cm)

The data related to plant height at panicle initiation, flowering, grain filling and maturity stages are depicted in table (4.1) and illustrated in figure (4.1).

In general, the plant height increased with the advancement of crop age and under treatment it varied significantly. In early duration genotypes Vasumati showed maximum plant height at flowering (126.9 cm) and at maturity stage (146.2 cm) while minimum plant height was recorded in Danteshwari at all the growth stages *i.e.* (78.6 cm) at panicle initiation, (84.4 cm) at flowering, (89.1 cm) at grain filling and (98.4 cm) at maturity stage.

In early duration genotypes plant height was recorded maximum in Vasumati (146.2 cm) while minimum plant height was recorded in Danteshwari (98.4 cm) at

maturity stage. In mid duration genotypes, Indira Sugandhit Dhan (113.2 cm) showed maximum plant height, while the minimum plant height was recorded R-1182-167-2-157-1 (100.3 cm) at maturity stage. Among late duration genotypes, Safri-17 showed significantly maximum plant height (152.1 cm), while the minimum plant height was recorded R-1060-1674-1-1 (102.0 cm) at maturity stage.

The plant height of all the genotypes was observed critically at different growth stages. The foliar spray of brassinolide helped in better rooting and enhanced uptake of more nutrients which leading to increased plant height in rice (Prakash *et al.* 2006). Similar results were obtained by Hebbalkar *et al.* (1997) and Asami *et al.* (2000).

4.1.2 Number of tillers plant⁻¹

The data related to number of tillers plant⁻¹ are presented in table (4.2).

The data revealed that maximum number of tillers plant⁻¹ observed in early duration genotypes was Danteshwari followed by R-979-1528-2-1, R-1037-649-1-1 and Vasumati at maturity stages, while minimum number of tillers plant⁻¹ was recorded in Vasumati in comparison with other genotypes. In mid duration genotypes, R-548-89-1 was recorded maximum number of tillers at maturity stage while minimum tillers showed Indira Sugandhit Dhan as compared to other genotypes. In late duration genotypes, R-1060-1674-1-1 showed maximum tillers while Dubraj showed minimum number of tillers plant⁻¹ at all the growth stages of plant.

The number of tillers recorded maximum was Danteshwari in early duration genotypes, R-548-89-1 in mid duration genotypes and R-1060-1674-1-1 in late duration genotypes while minimum was recorded in Vasumati, Indira Sugandhit Dhan and R-1060-1674-1-1 in the different duration rice genotypes respectively.

Generally genotypes have genetic inheritance capacity and Thirthalingappa (1999) reported that brassinolide increased number of tillers in rice. Similar results were also given by Prakash *et al.* (2006)

4.1.3 Number of leaves plant⁻¹

The data on number of leaves plant⁻¹ recorded at different growth stages are presented in table (4.3).

The data revealed that number of leaves plant⁻¹ recorded maximum in Danteshwari while minimum was recorded in Vasumati at all the growth stages of plant in early duration genotype groups. In mid duration genotypes, maximum number of leaves plant⁻¹ was observed in R-548-89-6 at panicle initiation stage, R-1072-360-1 at flowering and grain filling stages while minimum was recorded R-1182-167-2-157-1. Among late duration genotypes maximum number of leaves was recorded in R-1060-1674-1-1 at all growth stages while Dubraj showed minimum in comparison with other genotypes at all the growth stages.

Application of brassinolide as foliar spray helped to uptake more nutrients which leading to increased number of leaves in rice (Prakash *et al.*, 2006). These findings were also reported by Ramraj *et al.* (1997) in cotton and Yokota *et al.* (1986) in tobacco.

4.1.4 Flag leaf area (cm²)

The data related to flag leaf area at flowering stage is depicted in table (4.4) and illustrated in figure (4.2).

The data revealed that flag leaf area was recorded maximum in Vasumati (49.4 cm²) followed by Danteshwari (37.33 cm²) and R-1037-649-1-1 (35.33 cm²) while R-

979-1528-2-1 (32.50cm²) recorded minimum at flowering stage in early duration genotypes. In mid duration genotypes, R-1072-360-1 (37.53 cm²) recorded higher while R-1182-167-2-157-1 (33.6cm²) observed minimum flag leaf area at flowering stage. Among late duration genotypes, R-1072-360-1 (37.53 cm²) recorded higher while R-1182-167-2-157-1 (33.6 cm²) observed minimum flag leaf area in the plant⁻¹.

Generally, flag leaf area is considered to be one of the desirable parameter for photosynthetic efficiency and its partitioning. It is different from other leaves because prominent role play in starch formation and grain filling. The foliar spray of brassinolide resulted in the expansion of flag leaf area.

4.1.5 Dry weight of plant (g)

The data on dry weight plant⁻¹ at different growth stages are presented in table (4.5) and illustrated in figure (4.3).

The data revealed that dry weight of plant⁻¹ at different growth stages in early duration genotypes Vasumati showed higher dry weight in comparison to other genotypes while R-979-1528-2-1 found minimum dry weight at all the growth stages. In mid duration genotypes, R-1072-360-1 recorded maximum dry weight at grain filling (33.84 g) and maturity stage (40.15 g) while minimum dry weight observed R-1182-167-2-157-1 (23.59 g) found maximum followed by R-548-89-6 (23.44 g), R-1072-360-1 (21.80 g) and Indira Sugandhit Dhan (21.44 g) as compared to all other genotypes. In late duration genotypes, R-1249-1196-2-1 recorded maximum at grain filling (36.48 g) and maturity stage (42.65 g) while minimum was observed R-1060-1674-1-1 (7.50 g) at panicle initiation stage in comparison to all other genotypes. At flowering stage Safri-17 (28.06 g) found maximum dry weight while R-1060-1674-1-1 (21.30 g) recorded

minimum dry weight of plant⁻¹.

The dry weight of plant increased due to the carbon partitioning through source-sink relationship. Fujii and Saka *et al.* (2003) found that application of brassinosteroids improved source sink relation and other endogenous interactions in the rice crop. Similar results were also reported by Kim and Sa (1989) in rice and Lim *et al.* (1985) in fruit of tomato.

4.2 Physiological parameters

4.2.1 Leaf area index (LAI)

The related on leaf area index (LAI) at different growth stages are presented in table (4.6) and illustrated in figure (4.4).

The data revealed that the leaf area index recorded maximum Vasumati at all the growth stages while minimum was observed R-979-1528-2-1 (55.32) at panicle initiation stage in early duration genotypes. Among mid duration genotypes, maximum leaf area index was recorded Indira Sugandhit Dhan (62.50) while R-1072-360-1 (54.95) recorded minimum leaf area index as compared to other genotypes. In late duration genotypes, Safri-17 at recorded maximum leaf area index at maturity stage (106.6) and at flowering stage (102.9) in comparison to other genotypes while minimum was recorded R-1249-1196-2-1 at all the growth stages of plant.

Leaf area index (LAI) is the important parameters of growth analysis because it is measure canopy coverage per unit area which is directly involved in photosynthetic activity. Brassinolide application increased number of leaves which contributed higher leaf area and leaf area index. Similar results were also obtained by Ramraj *et al.* (1997) in cotton crop.

4.2.2 Crop growth rate (CGR)

The data recorded on crop growth rate (CGR) at different growth stages are presented in table (4.7).

The data revealed that crop growth rate at different growth stages were not differed significantly in early duration genotypes. Although, numerically Vasumati (0.0410) recorded maximum crop growth rate followed by R-1037-649-1-1 (0.0369), R-979-1528-2-1 (0.0343) and Danteshwari (0.0318) at panicle initiation stage while Danteshwari (0.0135) showed minimum at grain filling stage in comparison to other genotypes. At flowering stage Vasumati (0.0258) recorded maximum and R-1037-649-1-1 (0.0187) found minimum crop growth rate at flowering stage. In mid duration genotypes, R-1182-167-2-157-1 recorded maximum crop growth rate at all the growth stages and R-548-89-6 (0.0158) showed minimum crop growth rate at grain filling stage. Among the late duration genotypes, Safri-17 recorded maximum crop growth rate at panicle initiation (0.0470) and flowering stage (0.0665) while R-1060-1674-1-1 recorded minimum at flowering stage (0.0205) and at grain filling stage (0.0205) of crop.

The application of brassinolide enhanced various physiological activities which leading to increased crop growth rate Prakash *et al.* (2006)

4.2.3 Relative growth rate (RGR)

The data recorded on relative growth rate (RGR) at different growth stages are presented in table (4.8).

The data revealed that relative growth rate in early duration, mid duration and late duration genotypes not differed significantly at all the growth stages of crop.

Although, Vasumati showed maximum relative growth rate at panicle initiation (0.0410) and at flowering stage (0.0265) while minimum relative growth rate recorded Danteshwari at panicle initiation (0.0318) and R-1037-649-1-1 at flowering stage (0.0192) in early duration genotypes. At the grain filling stage, Vasumati (0.0016) possessed minimum relative growth rate in comparison to other early duration genotypes. In mid duration genotypes, R-1182-167-2-157-1 showed maximum relative growth rate at panicle initiation (0.0450) and at flowering stage (0.0265) while R-548-89-6 recorded minimum at panicle initiation (0.0265), R-1072-360-1 at flowering (0.0255) and R-1182-167-2-157-1 at grain filling (0.0012) stage. Relative growth rate was recorded in maximum Safri-17 at panicle initiation (0.0470) and flowering stage (0.0665) while Dubraj recorded minimum at panicle initiation (0.0302) and R-1060-1674-1-1 at flowering (0.0205) and at grain filling stage (0.0011) among late duration genotypes.

Prakash *et al.* (2006) reported that application of brassinolide enhanced physiological and biochemical processes which ultimately leading to increased relative growth rate in rice crop.

4.2.4 Net assimilation rate (NAR)

The data related on net assimilation rate (NAR) at different growth stages are presented in table (4.9).

The data revealed that net assimilation rate in early, mid and late duration genotypes not differed significantly at both panicle initiation and flowering stage. Whereas, numerically maximum net assimilation rate was recorded R-979-649-1-1 (0.0009) at panicle initiation and at flowering stage (0.0249) while Vasumati (0.0022)

found minimum at panicle initiation stage and R-1037-649-1-1 (0.0009) at flowering stage in early duration genotypes. In mid duration genotypes, R-1072-360-1 recorded maximum net assimilation rate at panicle initiation stage (0.0681) and Indira Sugandhit Dhan at flowering stage (0.0956) while R548-89-6 showed minimum net assimilation rate at both stages *i.e.* at panicle initiation (0.0011) and at flowering stage (0.0014). In late duration genotypes, maximum net assimilation rate recorded R-1060-1674-1-1 (0.0066) at panicle initiation and R-1249-1196-2-1 (0.0017) at flowering stage while Dubraj possessed minimum net assimilation rate at panicle initiation (0.0012) and R-1060-1674-1-1 (0.0011) at flowering stage.

Hayat *et al.* (2001) reported that application of brassinolide accelerated net photosynthesis rate in wheat. Similar results were obtained by Kuleava *et al.* (1991) in wheat and Rajasekaran *et al.* (1991) in jackpine.

4.3 Biochemical parameters

4.3.1 Chlorophyll content (SPAD)

The result related to chlorophyll content at different growth stages are presented in table (4.10).

The data indicated that total chlorophyll content in early duration genotypes R-979-1528-2-1 showed maximum chlorophyll content at panicle initiation (42.0) and flowering stage (40.52) while R-1037-649-1-1 (40.25) and Vasumati (36.0) recorded minimum at panicle initiation and flowering stage respectively. R-1037-649-1-1 observed maximum at grain filling stage (46.07) while Danteshwari observed minimum at (29.67). In mid duration genotypes, maximum chlorophyll content was recorded R-1072-360-1 at panicle initiation (45.30) and flowering stage (39.95) while Indira

Sugandhit Dhan recorded minimum at panicle initiation (38.9) and R-1182-167-2-157-1 observed minimum at flowering stage (38.1). In late duration genotypes, maximum chlorophyll content recorded Dubraj at panicle initiation (41.1), R-1060-1674-1 (39.7) at flowering and R-1249-1196-2-1 at grain filling stage (32.0) while R-1249-1196-2-1 showed minimum chlorophyll content at panicle initiation (37.9) and flowering stage (38.6) in comparison to other genotypes.

Maibangsa *et al.* (2000) investigated that brassinolide increased the accumulation of chlorophyll content and biochemical efficiency with increased assimilation in rice. Similar results were also observed by Prakash *et al.* (2002) in groundnut.

4.3.2 Carbohydrate content (%)

The result related to carbohydrate content is depicted in table (4.11) and illustrated in figure (4.5).

The data indicated that carbohydrate content recorded maximum Danteshwari (69.40) followed by Vasumati (68.90) and R-979-1528-2-1 (68.15) while R-1037-649-1-1 (66.35) recorded minimum carbohydrate content in early duration genotypes. In mid duration genotypes, maximum carbohydrate content recorded Indira Sugandhit Dhan (69.9) while R-1072-360-1 (63.3) found minimum in comparison to other genotypes. Among the late duration genotypes, Safri-17 (71.8) showed maximum carbohydrate content while R-1249-1196-2-1 (61.4) recorded minimum carbohydrate content in comparison to other genotypes.

Fujii and Saka (2001) reported that application of brassinolide increased carbohydrate in upper organs including the panicle of rice plant. Vardhini *et al.* (1998)

also found that spraying of brassinolide improved total sugar in groundnut. Similar results were also observed by Sairam *et al.* (1996) in rice and wheat.

4.4 Yield parameters

4.4.1 Number of productive tiller plant⁻¹

The data on number of productive tiller plant⁻¹ are presented in table (4.12).

The data revealed that Danteshwari (17.05) showed maximum number of tillers while Vasumati (13.37) recorded minimum in early duration genotypes. In mid duration genotypes, R-548-89-6 (16.45) recorded maximum followed by R-1072-360-1 (16.23) and R-1182-167-2-157-1 (16.15) while Indira Sugandhit Dhan (15.97) recorded minimum number of tiller plant⁻¹. Among all the late duration genotypes, R-1249-1196-2-1 (15.28) observed maximum while Dubraj (6.57) was found minimum number of tiller plant⁻¹.

Thirthalingappa *et al.* (1999) reported that application of brassinolide increased number of productive tiller plant⁻¹.

4.4.2 Panicle length (cm)

The data on panicle length are presented in table (4.13).

Panicle length was not differed significantly in early, mid and late duration genotypes. Although, numerically Danteshwari (25.35) recorded maximum while R-1037-649-1-1 (23.0) recorded minimum panicle length in early duration genotypes. In mid duration genotypes, R-1072-360-1 (30.41) showed maximum while Indira Sugandhit Dhan (24.31) recorded minimum panicle length. Among all the late duration genotypes, Safri-17 (26.34) recorded maximum while R-1060-1674-1-1 (24.89) found minimum panicle length in comparison to other genotypes.

Panicle length is an important yield attributing traits to decide the plant productivity.

4.4.3 Panicle weight (g)

The data on panicle weight are presented in table (4.14).

The data revealed that panicle weight was not differed significantly in early, mid and late duration genotypes. Although, numerically Danteshwari (1.87) recorded maximum while R-979-1528-2-1 (1.69) recorded minimum panicle weight in early duration genotypes. R-1072-360-1 (2.45) found maximum and Indira Sugandhit Dhan (1.53) recorded minimum panicle weight in mid duration genotypes. Among all the late duration genotypes, maximum panicle weight recorded R-1249-1196-2-1 (2.40) while Dubraj (1.55) showed minimum panicle weight in comparison to other genotypes.

4.4.4 Number of filled grains

The data related to number of filled grains are presented in table (4.15).

The data revealed that number of filled grains not significantly in early, mid and late duration genotypes. However, R-979-1528-2-1 (123.16) and Vasumati (123.16) recorded maximum while R-1037-649-1-1 (118.6) recorded minimum number of filled grains in early duration genotypes. In mid duration genotypes, R-548-89-6 (143.1) recorded higher while R-1072-360-1 (129.0) recorded minimum number of filled grains. Among late duration genotypes, R-1249-1196-2-1 (142.9) recorded maximum while Dubraj (96.5) showed minimum number of filled grains as compared to other genotypes.

The foliar application of brassinolide increased number of filled grains panicle⁻¹ reported by Yang *et al.* (1991) and Thirthalingappa *et al.* (1999).

4.4.5 Number of unfilled grains (%)

The data related to number of unfilled grains are presented in table (4.16).

The data revealed that number of unfilled grains not significantly in early, mid and late duration genotypes. Whereas numerically, Danteshwari (76.5) recorded maximum while R-979-1528-2-1 (41.9) recorded minimum number of unfilled grains in early duration genotypes. In mid duration genotypes, R-548-89-6 (76.7) found higher while R-1072-360-1 (67.6) recorded minimum number of unfilled grains. Among late duration genotypes, Safri-17 (100.3) recorded maximum while R-1060-1674-1-1 (45.7) showed minimum number of unfilled grains as compared to other genotypes.

4.4.6 Grain yield plot⁻¹(g)

The data on grain yield are presented in table (4.17) and illustrated in figure (4.6).

The data on grain yield revealed that all the early, mid and late duration genotypes significantly varied with respect to grain yield plot⁻¹. In early duration genotypes, Danteshwari (2477.50) was found significantly superior for exhibiting the higher grain yield over all other genotypes which followed by R-979-1528-2-1 (2350.00) and R-1037-649-1-1 (2275.00) while minimum grain yield was found in Vasumati (2087.50) genotypes. R-1182-167-2-157-1 (2575.00) recorded maximum grain yield over all the other genotypes while Indira Sugandhit Dhan (2087.5) in mid duration genotypes. Among all the late duration genotypes, R-1249-1196-2-1 (2887.5) significantly superior over all other genotypes while Dubraj (1975.0) recorded minimum grain yield in comparison to other genotypes.

The ability of exogenously applied brassinolide to improved crop yield of rice

reported by Krishnan *et al.* (1999). Similarly Ebenezer *et al.* (2000) also found that brassinolide increased yield of rice grains. These findings were also reported by Ramraj *et al.* (1997).

4.4.7 Harvest index (%)

The data related to harvest index is depicted in table (4.18) and illustrated in figure (4.7).

The data revealed that all the early, mid and late duration genotypes significantly varied with respect to harvest index. Vasumati (36.09) significantly showed higher followed by R-979-1528-2-1 (33.65), Danteshwari (31.38) while R-1037-649-1-1 (26.79) recorded minimum harvest index. R-1249-1196-2-1 (44.66) found significantly maximum followed by Dubraj (37.75) and Safri-17 (34.97) while R-1060-1674-1-1 (27.38) recorded minimum harvest index as compared to other genotypes in late duration genotypes.

The foliar spray of brassinolide is the most effective in harvest index. Schilling *et al.* (1991) also reported in wheat and Fujii *et al.* (1991) in Groundnut.

CHAPTER-V

SUMMARY, CONCLUSIONS AND SUGGESTIONS FOR FUTURE RESEARCH WORK

The field experiment was laid down in Factorial Randomized Block Design with two replications. Three major groups early, medium and long duration of rice consist of three genotypes in early group, four genotypes in medium group and five genotypes in late group. Therefore, combination of total twelve genotypes and two treatments *i.e.* control and brassinolide were taken to “Impact of growth substance brassinolide on morpho-physiological and yield attributes of rice (*Oryza sativa* L.) genotypes” in *Kharif* 2007. With a view to study the impact on morpho-physiological and yield potential in rice genotypes.

The direct sowing of paddy was done in rainfed low land situation on 28 July 2007. The row to row spacing was 15 cm and the fertilizer dose N: P: K was 100:80:60. The morpho-physiological and yield attributes were recorded for plant height, number of leaf, number of tillers, flag leaf area, dry weight of plant, leaf area index, crop growth rate, relative growth rate, net assimilation rate, panicle weight, panicle length, number of filled grain, number of unfilled grain, grain yield, and harvest index. The effect of brassinolide was studied at the different growth stages *i.e.* panicle initiation (PI), flowering, grain filling and maturity stage.

Chlorophyll content was recorded at panicle initiation, flowering and grain filling stage in each twelve rice genotypes in the field. Carbohydrate content was also observed at maturity stage.

The salient findings of the experiment are summarized below:-

Plant height was significantly increased by brassinolide spray which resulting better plant growth. The maximum plant height was observed in Vasumati (early duration genotypes), Indira Sugandhit Dhan (mid duration genotypes) and Safri-17 (late duration genotypes) and minimum plant height was observed in Danteshwari

(early duration genotypes), R-1182-167-2-157-1 (mid duration genotypes) and R-1060-1674-1-1 (late duration genotypes) in all the growth stages of plant.

The number of tillers plant⁻¹ was significantly varied in all the genotypes and treatments. The foliar application of brassinolide more effective and increased the number of tillers. The maximum number of tiller was observed in Danteshwari (early duration genotypes), R-548-89-6 (mid duration genotypes) and R-1060-1674-1 (late duration genotypes) and minimum tillers were observed in Vasumati (early duration genotypes), Indira Sugandhit Dhan (mid duration genotypes) and Dubraj (late duration genotypes) in all the growth stages of plant.

The number of leaves plant⁻¹ was significantly varied in all the genotypes and treatments. The foliar application of brassinolide more effective and increased the number of leaves. The maximum leaves were observed in Danteshwari (early duration genotypes), R-548-89-6 (mid duration genotypes) and R-1060-1674-1 (late duration genotypes) and minimum leaves were observed in Vasumati (early duration genotypes), R-1182-167-2-157-1 (mid duration genotypes) and Dubraj (late duration genotypes) in all the growth stages of plant.

The flag leaf area was significantly varied in all the genotypes and treatments. The foliar application of brassinolide more effective and increased the flag leaf area. The maximum flag leaf area was observed in Vasumati (early duration genotypes), R-1072-360-1 (mid duration genotypes) and Safri-17 (late duration genotypes). Minimum flag leaf area was observed in R-979-1528-2-1 (early duration genotypes), R-1182-167-2-157-1 (mid duration genotypes) and R-1060-1674-1 (late duration genotypes) at flowering stage.

The dry weight of plant was significantly varied in all the genotypes and treatments. The foliar application of brassinolide more effective and increased the dry weight. The maximum dry weight of plant was observed in Vasumati (early duration genotypes), R-1072-360-1 (mid duration genotypes) and R-1249-1196-2-1 (late duration genotypes). Minimum dry weight of plant was observed in R-979-1528-2-1 (early duration genotypes), Indira Sugandhit Dhan (mid duration genotypes) and R-1060-1674-1 (late duration genotypes) in all the growth stages of plant.

The leaf area index was significantly varied in all early, mid and late genotypes and treatments. The foliar application of brassinolide more effective and increased the leaf area index. The maximum leaf area index was observed in Vasumati (early duration genotypes), Indira Sugandhit Dhan (mid duration genotypes) and Safri-17 (late duration genotypes) and minimum leaf area index was observed in Danteshwari (early duration genotypes), R-1072-360-1 (mid duration genotypes) and R-1249-1196-2-1 (late duration genotypes) in all the growth stages of plant.

The crop growth rate was not differed significantly in all early, mid and late genotypes and treatments. However numerically maximum crop growth rate was observed in Vasumati (early duration genotypes), R-1182-167-2-157-1 (mid duration genotypes) and Safri-17 (late duration genotypes) and minimum crop growth rate Danteshwari (early duration genotypes), R-548-89-6 (mid duration genotypes) and R-1060-1674-1-1 (late duration genotypes) in all the growth stages of plant.

The relative growth rate was also not differed significantly in all early, mid

and late genotypes and treatments. Although, numerically maximum relative growth rate was observed in Vasumati (early duration genotypes), R-1182-167-2-157-1 (mid duration genotypes) and Safri-17 (late duration genotypes) and minimum relative growth rate Danteshwari (early duration genotypes), R-548-89-6 (mid duration genotypes) and Dubraj (late duration genotypes) in all the growth stages of plant.

The net assimilation rate was also not differed significantly in all early, mid and late genotypes and treatments. The maximum net assimilation rate was observed in R-979-1528-2-1 (early duration genotypes), Indira Sugandhit Dhan (mid duration genotypes) and R-1060-1674-1-1 (late duration genotypes) and minimum net assimilation rate R-1037-649-1-1 (early duration genotypes), R-548-89-6 (mid duration genotypes) and Dubraj (late duration genotypes) in all the growth stages of plant.

The carbohydrate content was significantly varied in all the genotypes and treatments. The foliar application of brassinolide more effective and increased the carbohydrate content. The maximum carbohydrate content was observed in R-979-1528-2-1 (early duration genotypes), Indira Sugandhit Dhan (mid duration genotypes) and Safri-17 (late duration genotypes). Minimum carbohydrate content was observed in R-1037-649-1-1 (early duration genotypes), R-1072-360-1 (mid duration genotypes) and R-1249-1196-2-1 (late duration genotypes).

The chlorophyll content was not differed significantly varied in all the early, mid and late genotypes and treatments. The maximum chlorophyll content was observed in R-1037-649-1-1 (early duration genotypes), R-1072-360-1 (mid duration genotypes) and Dubraj (late duration genotypes). Minimum chlorophyll content was

observed in Danteshwari (early duration genotypes), Indira Sugandhit Dhan (mid duration genotypes) and R-1060-1674-1-1 (late duration genotypes) at panicle initiation, flowering and grain filling stage.

The grain yield was significantly varied in all the genotypes and treatments. The foliar application of brassinolide more effective and increased the grains yield. The maximum grain yield was observed in Danteshwari (early duration genotypes), R-1182-167-2-157-1 (mid duration genotypes) and R-1249-1196-2-1 (late duration genotypes). Minimum grain yield was observed in Vasumati (early duration genotypes), Indira Sugandhit Dhan (mid duration genotypes) and Dubraj (late duration genotypes).

The harvest index was significantly varied in all the genotypes and treatments. The foliar application of brassinolide more effective and increased the harvest index. The maximum harvest index was observed in R-979-1528-2-1 (early duration genotypes), R-1182-167-2-157-1 (mid duration genotypes) and R-1249-1196-2-1 (late duration genotypes). Minimum harvest index was observed in R-1037-649-1-1 (early duration genotypes), R-548-89-6 (mid duration genotypes) and R-1060-1674-1-1 (late duration genotypes).

Conclusions

In light of the results obtained, it can be conclude that the genotypes variability do exist regarding the morpho-physiological, biochemical and other determinates at various stages of the crop.

1. Brassinolide emerged as magic chemicals that could agricultural

production at an unprecedented rate by increasing a rate of growth and development which helped in removing or circumventing many of the barriers imposed by genetics and the environment on rice genotypes.

2. Morphological behavior of used rice genotypes varied significantly. However, plant height, number of leaves and tillers, dry weight of plant, grain yield were significantly improved effect of brassinolide was most effective for almost all rice genotypes.
3. Application of brassinolide significantly improved growth analysis *i.e.* LAI and HI in almost all the rice genotypes.
4. It was observed that foliar application of brassinolide was found most effective to improved carbohydrate content of almost all rice genotypes significantly.
5. The entire yield attributing characters number *viz.* number of filled grain, weight of panicles was observed to be the best by brassinolide spray.

Suggestions for future research work

Since the result of present investigation is based on the work of one season, it cannot be entirely accepted to be conclusive. However following suggestions were stressed in future.

1. The experiment should be conducted for few more years to reach more confirmed conclusion regarding the results obtained.
2. Growth substance and their combination should be tested with different concentrations.
3. Worked on evaluating the spraying of growth regulator at different stages of the crop should be undertaken.
4. Influence of plant growth regulator on certain biochemical parameters required for further studies.

Due to lack of knowledge and high cost of plant growth regulators except vegetable growers a large group of farmers are not used. Some cheapest source has to be developed with intensive extension work to be popularized.

“IMPACT OF GROWTH SUBSTANCE BRASSINOLIDE ON MORPHO-PHYSIOLOGICAL AND YIELD ATTRIBUTES OF RICE (*Oryza sativa* L.) GENOTYPES”

By

ANITA CHOUDHARY

ABSTRACT

The present investigation entitled “Impact of growth substance brassinolide on morpho-physiological and yield attributes of rice (*Oryza sativa* L.) genotypes” was carried out at the Instructional Farm, Department of Plant Physiology IGKV, Raipur (C.G.) during *kharif* season 2007. The experiment was laid out in Factorial Randomized Block Design in two replication with twelve early, mid and late duration genotypes namely R-1037-649-1-1, Danteshwari, R-979-1528-2-1, Vasumati, Indira Sugandhit Dhan, R-1182-167-2-157-1, R-548-89-6, R-1072-360-1, Safri-17, Dubraj, R-1249-1196-2-1 and R-1060-1674-1-1 respectively. The experiment was done with explicit to find out the impact of foliar application of brassinolide on morpho-physiological and yield potential of these genotypes at two levels *i.e.* T₁- Control and T₂-Brassinolide. The effect of brassinolide was studied at panicle initiation (PI), flowering, grain filling and maturity stage of crop.

All the early, mid and late duration genotypes differed significantly in various morpho-physiological as well as yield attributing characters like plant height, number of tillers, number of leaves, flag leaf area, dry weight of plant, leaf area index, chlorophyll content, carbohydrate content, panicle length, panicle weight, number of filled grain, grain yield and harvest index (HI).

The results revealed that early, mid and late duration genotypes Vasumati, Indira Sugandhit Dhan and Safri-17 exhibited maximum plant height and Danteshwari, R-548-89-6 and R-1060-1674-1 recorded more number of tiller plant⁻¹ and number of leaves plant⁻¹ respectively at all the growth stage of plant. Genotypes Vasumati, R-1072-360-1 and Safri-17 exhibited maximum flag leaf area at flowering stage. Vasumati, R-1072-360-1, Indira Sugandhit Dhan, R-1249-1196-2-1 and Safri-17 recorded maximum leaf area index and dry weight of plant at all the growth stages. The harvest index was found higher in R-979-1528-2-1, R-1182-167-2-157-1 and R-1249-1196-2-1 respectively.

In yield attributing characters early, mid and late duration genotypes Danteshwari, R-1182-167-2-157-1 and R-1249-1196-2-1 respectively produced higher grain yield. The biochemical parameter for carbohydrate content was recorded maximum in R-979-1528-2-1, Indira Sugandhit Dhan and Safri-17 respectively.

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LIST OF ABBREVIATIONS

ABBREVIATIONS	DESCRIPTION
%	Per cent
ANOVA	Analysis of Variance
°C	Degree Celsius
CD	Critical difference
cm	Centimeter
DAS	Days After Sowing
DAT	Days After Transplanting
<i>et al.</i>	And others/ and co-workers
Fig.	Figure
g	Gram
ha	Hectare
<i>i.e.</i>	That is
kg	Kilogram
m	Meter
NS	Non significant
q	Quintal
SEm	Standard error of mean
S ₁	Panicle initiation (PI) stage
S ₂	Flowering stage
S ₃	Grain filling stage
S ₄	Maturity stage
<i>viz.</i>	Namely

Appendix I: Weekly meteorological observations recorded during the crop season.

Week number	Temperature (°C)		Rainfall (mm)	Relative humidity (%)		Wind velocity (kmph)	Sun shine (hours)
	Maximum (°C)	Minimum (°C)		RH I (%)	RH II (%)		
27	29.9	24.9	80.6	86	77	14.0	2.5
28	30.2	24.8	74.6	92	79	10.6	2.5
29	31.9	25.5	10.2	89	70	9.2	1.6
30	32.1	24.5	95.1	92	69	6.3	4.2
31	31.8	25.3	10.2	90	69	5.9	3.4
32	29.7	24.9	110.9	92	83	9.4	2.3
33	29.4	24.6	4.6	91	73	10.5	1.6
34	30.2	24.5	67.0	95	79	4.8	5.6
35	30.0	25.3	61.3	94	79	3.7	3.6
36	30.2	24.3	91.7	94	80	7.2	2.5
37	31.2	24.7	34.8	94	73	4.6	3.9
38	31.5	24.2	23.6	90	72	4.6	7.0
39	30.0	24.0	45.0	94	73	5.6	4.1
40	31.4	24.1	29.0	91	68	3.1	5.4
41	31.6	20.6	0	91	44	1.9	7.6
42	30.8	19.4	0	93	42	1.9	9.0
43	30.8	16.0	0	93	36	2.1	9.6
44	30.5	20.9	7.4	93	57	3.6	7.0
45	30.7	15.6	0	93	36	1.6	8.9
46	29.7	14.2	0	89	39	2.5	8.9
47	28.0	11.6	0	89	29	2.1	8.5

Appendix I: Weekly meteorological observations recorded during the crop season.

Week number	Temperature (°C)		Rainfall (mm)	Relative humidity (%)		Wind velocity (kmph)	Sun shine (hours)
	Maximum (°C)	Minimum (°C)		RH I (%)	RH II (%)		
27	29.9	24.9	80.6	86	77	14.0	2.5
28	30.2	24.8	74.6	92	79	10.6	2.5
29	31.9	25.5	10.2	89	70	9.2	1.6
30	32.1	24.5	95.1	92	69	6.3	4.2
31	31.8	25.3	10.2	90	69	5.9	3.4
32	29.7	24.9	110.9	92	83	9.4	2.3
33	29.4	24.6	4.6	91	73	10.5	1.6
34	30.2	24.5	67.0	95	79	4.8	5.6
35	30.0	25.3	61.3	94	79	3.7	3.6
36	30.2	24.3	91.7	94	80	7.2	2.5
37	31.2	24.7	34.8	94	73	4.6	3.9
38	31.5	24.2	23.6	90	72	4.6	7.0
39	30.0	24.0	45.0	94	73	5.6	4.1
40	31.4	24.1	29.0	91	68	3.1	5.4
41	31.6	20.6	0	91	44	1.9	7.6
42	30.8	19.4	0	93	42	1.9	9.0
43	30.8	16.0	0	93	36	2.1	9.6
44	30.5	20.9	7.4	93	57	3.6	7.0
45	30.7	15.6	0	93	36	1.6	8.9
46	29.7	14.2	0	89	39	2.5	8.9
47	28.0	11.6	0	89	29	2.1	8.5

Table 4.1: Effect of brassinolide on plant height (cm) of rice genotypes at different growth stages

Varieties	Growth stage	Control	Brassinolide	Varietal Effect
R-1037-649-1-1	S ₁	83.65	83.90	83.77
	S ₂	87.35	87.80	87.57
	S ₃	92.18	93.70	92.94
	S ₄	99.85	102.70	101.27
Danteshwari	S ₁	75.80	81.90	78.62
	S ₂	83.05	85.90	84.47
	S ₃	87.60	90.75	89.17
	S ₄	103.90	101.40	98.47
R-979-1528-2-1	S ₁	78.85	83.40	81.12
	S ₂	94.20	96.80	95.50
	S ₃	98.80	100.50	99.65
	S ₄	103.90	105.40	104.65
Indira Sugandhit Dhan	S ₁	79.85	82.00	80.92
	S ₂	101.80	105.65	103.72
	S ₃	108.00	109.75	108.87
	S ₄	111.90	114.60	113.25
R-1182-167-2-157-1	S ₁	80.64	82.85	81.74
	S ₂	91.45	92.80	92.12
	S ₃	95.90	97.65	96.77
	S ₄	99.65	100.95	100.30
Vasumati	S ₁	91.96	92.75	92.35
	S ₂	104.90	105.80	105.35
	S ₃	126.20	127.65	126.92
	S ₄	144.65	147.90	146.27
R-1249-1196-2-1	S ₁	82.68	85.00	83.84
	S ₂	87.80	89.65	88.72
	S ₃	93.85	95.80	126.92
	S ₄	100.90	104.90	102.90
R-548-89-6	S ₁	85.35	87.75	86.55
	S ₂	91.00	91.60	91.30
	S ₃	95.80	98.00	96.90
	S ₄	100.60	104.90	102.62
R-1060-1674-1-1	S ₁	82.58	83.95	83.26
	S ₂	87.00	87.70	87.35
	S ₃	95.90	97.90	96.90
	S ₄	101.15	102.90	102.02

Continued.....

Varieties	Growth stage	Control	Brassinolide	Varietal Effect
Safri-17	S ₁	102.15	105.00	103.57
	S ₂	117.75	120.65	119.20
	S ₃	130.75	132.80	131.77
	S ₄	149.60	154.65	152.12
Dubraj	S ₁	97.50	99.80	98.65
	S ₂	105.80	108.65	107.22
	S ₃	125.70	128.65	127.17
	S ₄	144.60	149.60	147.10
R-1072-360-1	S ₁	86.85	88.00	94.55
	S ₂	88.65	89.65	101.80
	S ₃	92.90	94.55	93.72
	S ₄	99.65	101.80	100.72
Treatment effect	S ₁	85.65	87.98	
	S ₂	95.06	96.88	
	S ₃	103.63	105.64	
	S ₄	112.68	115.93	

Stages	Varieties (V)				Treatments (T)				Interaction (V×T)			
	S ₁	S ₂	S ₃	S ₄	S ₁	S ₂	S ₃	S ₄	S ₁	S ₂	S ₃	S ₄
SEm±	0.19	0.18	0.12	0.15	0.48	0.44	0.30	0.39	0.68	0.63	0.43	0.55
CD at 5 %	0.57	0.53	0.36	0.46	1.41	1.30	0.89	1.14	1.99	NS	NS	1.61

Table 4.2: Effect of brassinolide on number of tillers plant⁻¹ of rice genotypes at different growth stages

Varieties	Growth stage	Control	Brassinolide	Varietal effect
R-1037-649-1-1	S ₁	11.95	14.83	13.39
	S ₂	15.99	16.83	16.41
	S ₃	17.16	17.83	17.49
	S ₄	18.16	18.83	18.49
Danteshwari	S ₁	12.96	14.99	13.98
	S ₂	16.66	16.99	16.83
	S ₃	17.99	18.32	18.16
	S ₄	18.49	19.33	18.91
R-979-1528-2-1	S ₁	10.95	14.10	12.52
	S ₂	15.83	16.16	15.99
	S ₃	17.66	17.99	17.83
	S ₄	18.33	18.83	18.58
Indira Sugandhit Dhan	S ₁	12.10	13.66	12.88
	S ₂	15.66	16.16	15.91
	S ₃	15.99	16.99	16.49
	S ₄	17.16	17.83	17.49
R-1182-167-2-157-1	S ₁	11.95	13.99	12.97
	S ₂	15.24	15.99	15.62
	S ₃	15.99	16.99	16.49
	S ₄	17.33	18.49	17.91
Vasumati	S ₁	7.96	8.83	8.39
	S ₂	9.83	10.99	10.41
	S ₃	11.83	12.16	11.99
	S ₄	12.16	12.99	17.91
R-1249-1196-2-1	S ₁	11.95	11.99	11.97
	S ₂	13.99	14.99	14.49
	S ₃	15.83	15.83	15.83
	S ₄	16.16	17.66	16.91
R-548-89-6	S ₁	13.65	14.99	14.32
	S ₂	15.66	16.99	16.33
	S ₃	16.16	17.66	17.33
	S ₄	17.99	18.61	18.07
R-1060-1674-1-1	S ₁	12.95	14.24	13.59
	S ₂	14.99	15.99	15.49
	S ₃	16.16	16.49	16.33
	S ₄	17.33	17.83	17.58

Continued.....

Varieties	Growth stage	Control	Brassinolide	Varietal Effect
Safri-17	S ₁	6.95	7.95	7.45
	S ₂	8.66	9.99	9.33
	S ₃	10.30	11.16	10.73
	S ₄	11.49	12.33	11.91
Dubraj	S ₁	4.66	4.99	4.83
	S ₂	5.83	6.83	6.33
	S ₃	7.33	7.66	7.49
	S ₄	7.83	8.16	7.99
R-1072-360-1	S ₁	12.95	13.95	13.45
	S ₂	15.83	16.66	16.24
	S ₃	16.99	17.66	17.33
	S ₄	17.99	18.36	18.17
Treatment effect	S ₁	10.91	12.37	
	S ₂	13.68	14.55	
	S ₃	15.02	15.56	
	S ₄	15.87	16.56	

Stages	Varieties (V)				Treatments (T)				Interaction (V×T)			
	S ₁	S ₂	S ₃	S ₄	S ₁	S ₂	S ₃	S ₄	S ₁	S ₂	S ₃	S ₄
SEm±	0.15	0.04	0.05	0.04	0.38	0.11	0.12	0.11	0.55	0.16	0.17	0.16
CD at 5 %	0.46	0.13	0.36	0.46	1.13	0.33	0.35	0.33	-	-	-	0.47

Table 4.3: Effect of brassinolide on number of leaves plant⁻¹ of rice genotypes at different growth stages

Varieties	Growth stage	Control	Brassinolide	Varietal Effect
R-1037-649-1-1	S ₁	24.16	58.49	41.33
	S ₂	62.49	67.33	64.91
	S ₃	67.49	71.49	70.81
Danteshwari	S ₁	51.49	59.16	55.33
	S ₂	63.66	65.49	64.91
	S ₃	69.49	70.66	70.83
R-979-1528-2-1	S ₁	41.16	51.49	46.33
	S ₂	61.33	63.49	62.41
	S ₃	69.16	73.16	71.16
Indira Sugandhit Dhan	S ₁	46.83	53.16	49.99
	S ₂	60.16	61.49	60.83
	S ₃	64.83	67.99	66.41
R-1182-167-2-157-1	S ₁	29.49	52.49	49.66
	S ₂	57.49	61.49	59.49
	S ₃	62.49	65.33	63.91
Vasumati	S ₁	46.83	33.16	31.33
	S ₂	61.49	42.00	39.74
	S ₃	46.33	48.49	47.41
R-1249-1196-2-1	S ₁	42.66	46.49	44.58
	S ₂	59.49	58.66	56.49
	S ₃	62.00	63.66	62.83
R-548-89-6	S ₁	53.99	57.49	55.74
	S ₂	33.33	66.49	63.41
	S ₃	66.16	70.33	68.24
R-1060-1674-1-1	S ₁	49.16	54.49	51.83
	S ₂	24.99	61.33	69.41
	S ₃	63.83	65.33	64.58

Continued.....

Varieties	Growth stage	Control	Brassinolide	Varietal Effect
Safri-17	S ₁	25.49	29.16	27.33
	S ₂	61.49	39.16	36.24
	S ₃	42.49	44.49	43.49
Dubraj	S ₁	18.49	21.49	19.99
	S ₂	53.14	27.33	26.16
	S ₃	29.49	30.49	29.99
R-1072-360-1	S ₁	49.99	53.50	51.74
	S ₂	61.49	66.49	63.99
	S ₃	68.33	71.49	69.91
Treatment effect	S ₁	39.98	47.55	
	S ₂	53.14	56.73	
	S ₃	59.39	61.91	

Stages	Varieties (V)			Treatments (T)			Interaction (T×V)		
	S ₁	S ₂	S ₃	S ₁	S ₂	S ₃	S ₁	S ₂	S ₃
SEm±	1.26	0.17	0.17	3.09	0.42	0.37	4.38	0.59	0.52
CD at 5 %	3.70	9.06	0.44	0.50	1.24	1.08	-	1.75	-

Table 4.4: Effect of brassinolide on flag leaf area (cm²) of rice genotypes at flowering stage

Varieties	Control	Brassinolide	Varietal Effect
R-1037-649-1-1	34.86	35.81	35.33
Danteshwari	36.94	37.80	37.37
R-979-1528-2-1	32.90	32.11	32.50
Indira Sugandhit Dhan	34.84	36.55	35.69
R-1182-167-2-157-1	31.32	35.93	33.62
Vasumati	47.36	51.59	49.47
R-1249-1196-2-1	38.98	32.01	35.49
R-548-89-6	35.15	39.23	37.19
R-1060-1674-1-1	33.35	36.95	35.15
Safri-17	49.03	52.01	50.52
Dubraj	47.59	49.14	48.36
R-1072-360-1	37.18	37.89	37.53
Treatment effect	38.29	39.75	
	Variety (V)	Treatment (T)	Interaction (V×T)
SEm±	0.27	0.67	0.95
CD at 5 %	0.80	1.96	2.78

Table 4.5: Effect of brassinolide on dry weight (g) of rice genotypes at different growth stages

Varieties	Growth stage	Control	Brassinolide	Varietal Effect
R-1037-649-1-1	S ₁	8.18	6.93	7.56
	S ₂	22.07	20.82	21.45
	S ₃	29.77	32.30	31.04
	S ₄	38.02	40.06	39.04
Danteshwari	S ₁	8.04	7.92	7.98
	S ₂	24.17	21.64	22.91
	S ₃	19.07	32.30	33.07
	S ₄	37.91	39.82	38.87
R-979-1528-2-1	S ₁	6.39	6.27	6.33
	S ₂	19.07	17.82	18.44
	S ₃	31.79	28.85	33.07
	S ₄	36.16	35.44	35.80
Indira Sugandhit Dhan	S ₁	9.81	9.32	9.57
	S ₂	21.77	21.33	21.44
	S ₃	21.33	31.68	26.51
	S ₄	38.94	40.16	39.55
R-1182-167-2-157-1	S ₁	7.60	7.11	7.37
	S ₂	26.01	21.18	23.59
	S ₃	35.02	31.37	33.19
	S ₄	40.71	38.43	39.57
Vasumati	S ₁	9.61	9.46	9.53
	S ₂	24.95	23.66	24.30
	S ₃	34.09	36.88	35.48
	S ₄	44.25	41.05	42.62
R-1249-1196-2-1	S ₁	11.81	12.17	11.99
	S ₂	24.08	25.00	24.54
	S ₃	37.77	35.19	36.48
	S ₄	45.25	41.05	42.65
R-548-89-6	S ₁	8.05	9.00	8.53
	S ₂	21.78	25.11	23.44
	S ₃	31.78	30.06	30.92
	S ₄	40.24	37.73	38.99
R-1060-1674-1-1	S ₁	8.20	6.81	7.50
	S ₂	20.78	21.82	21.30
	S ₃	30.65	32.86	31.75
	S ₄	36.82	41.04	38.93

Continued.....

Varieties	Growth stage	Control	Brassinolide	Varietal Effect
Safri-17	S ₁	8.14	9.41	8.77
	S ₂	27.06	29.06	28.06
	S ₃	34.70	27.21	35.10
	S ₄	41.39	41.21	41.30
Dubraj	S ₁	9.63	11.11	10.37
	S ₂	25.27	27.21	26.24
	S ₃	31.89	33.03	32.46
	S ₄	42.07	41.06	41.57
R-1072-360-1	S ₁	10.03	11.06	10.54
	S ₂	22.85	20.75	21.80
	S ₃	34.91	32.78	33.84
	S ₄	39.42	40.38	40.15
Treatment effect	S ₁	8.79	8.88	
	S ₂	23.30	22.95	
	S ₃	32.16	32.86	
	S ₄	40.15	40.38	

Stages	Varieties (V)				Treatments (T)				Interaction (V×T)			
	S ₁	S ₂	S ₃	S ₄	S ₁	S ₂	S ₃	S ₄	S ₁	S ₂	S ₃	S ₄
SEm±	0.11	0.18	0.20	0.21	0.28	0.44	0.48	0.51	0.40	0.62	0.69	0.73
CD at 5 %			-	-	0.58	0.46			0.83	1.29	1.43	1.51
									1.18	1.82	2.02	2.14

Table 4.6: Effect of brassinolide on leaf area index (LAI) of rice genotypes at different growth stages

Varieties	Growth stage	Control	Brassinolide	Varietal Effect
R-1037-649-1-1	S ₁	58.50	61.45	59.97
	S ₂	63.40	63.65	63.52
	S ₃	70.31	64.90	67.60
Danteshwari	S ₁	46.45	65.40	55.92
	S ₂	52.60	66.80	59.70
	S ₃	49.30	69.55	59.42
R-979-1528-2-1	S ₁	59.20	51.45	55.32
	S ₂	62.55	56.85	59.70
	S ₃	63.65	65.35	64.50
Indira Sugandhit Dhan	S ₁	52.80	57.15	54.97
	S ₂	56.55	59.50	58.02
	S ₃	61.70	63.30	62.50
R-1182-167-2-157-1	S ₁	46.80	57.50	52.15
	S ₂	47.25	64.00	55.62
	S ₃	55.12	67.80	61.46
Vasumati	S ₁	62.30	62.65	62.47
	S ₂	66.10	69.50	67.80
	S ₃	77.80	75.70	76.75
R-1249-1196-2-1	S ₁	44.10	55.40	49.75
	S ₂	49.13	57.80	53.46
	S ₃	52.00	60.10	56.05
R-548-89-6	S ₁	51.00	53.00	52.00
	S ₂	53.75	55.05	54.40
	S ₃	58.00	58.75	58.37
R-1060-1674-1-1	S ₁	49.10	56.00	52.95
	S ₂	53.10	57.70	55.40
	S ₃	57.05	61.15	59.10

Continued.....

Varieties	Growth stage	Control	Brassinolide	Varietal Effect
Safri-17	S ₁	81.45	67.10	74.27
	S ₂	107.90	98.00	102.95
	S ₃	110.10	103.10	106.60
Dubraj	S ₁	79.00	77.00	78.00
	S ₂	81.35	86.05	83.70
	S ₃	94.95	97.80	96.37
R-1072-360-1	S ₁	46.10	48.70	47.40
	S ₂	49.10	51.50	50.30
	S ₃	51.90	58.00	54.95
Treatment effect	S ₁	56.46	59.40	
	S ₂	61.89	65.53	
	S ₃	66.82	70.45	

Stages	Varieties (V)			Treatments (T)			Interaction (V×T)					
	S ₁	S ₂	S ₃	S ₁	S ₂	S ₃	S ₁	S ₂	S ₃			
SEm±	0.90	0.23	0.27	2.21	0.58	0.66	0.11	0.28	0.40			
CD at 5 %		2.63	0.69	0.79		6.46	1.70	1.95		-	0.83	1.18

Table 4.7: Effect of brassinolide on crop growth rate ($\text{g}^{-1} \text{plant}^{-1} \text{day}^{-1}$) of rice genotypes at different growth stages

Varieties	Growth stage	Control	Brassinolide	Varietal Effect
R-1037-649-1-1	S ₁	0.0367	0.0370	0.0369
	S ₂	0.0195	0.0180	0.0187
	S ₃	0.0155	0.0210	0.0183
Danteshwari	S ₁	0.0405	0.0230	0.0318
	S ₂	0.0245	0.0140	0.0192
	S ₃	0.0135	0.0135	0.0135
R-979-1528-2-1	S ₁	0.0350	0.0335	0.0343
	S ₂	0.0310	0.0190	0.0250
	S ₃	0.0135	0.0180	0.0157
Indira Sugandhit Dhan	S ₁	0.0390	0.0400	0.0395
	S ₂	0.0145	0.0270	0.0208
	S ₃	0.0155	0.0155	0.0155
R-1182-167-2-157-1	S ₁	0.0505	0.0395	0.0450
	S ₂	0.0255	0.0275	0.0265
	S ₃	0.0620	0.0120	0.0370
Vasumati	S ₁	0.0420	0.0400	0.0410
	S ₂	0.0275	0.0240	0.0258
	S ₃	0.0145	0.0190	0.0168
R-1249-1196-2-1	S ₁	0.0325	0.0390	0.0357
	S ₂	0.0375	0.0305	0.0340
	S ₃	0.0190	0.0150	0.0170
R-548-89-6	S ₁	0.0340	0.0250	0.0295
	S ₂	0.0280	0.0240	0.0260
	S ₃	0.0170	0.0145	0.0158
R-1060-1674-1-1	S ₁	0.0340	0.0515	0.0428
	S ₂	0.0270	0.0140	0.0205
	S ₃	0.0110	0.0140	0.0107

Continued.....

Varieties	Growth stage	Control	Brassinolide	Varietal Effect
Safri-17	S ₁	0.0535	0.0405	0.0470
	S ₂	0.1075	0.0255	0.0665
	S ₃	0.0125	0.0160	0.0142
Dubraj	S ₁	0.0330	0.0275	0.0302
	S ₂	0.0210	0.0330	0.0270
	S ₃	0.0165	0.0190	0.0178
R-1072-360-1	S ₁	0.0405	0.0270	0.0338
	S ₂	0.060	0.0250	0.0255
	S ₃	0.0185	0.0175	0.0180
Treatment effect	S ₁	0.0393	0.0353	
	S ₂	0.0325	0.0235	
	S ₃	0.0191	0.0159	

Stages	Varieties (V)			Treatments (T)			Interaction (V×T)		
	S ₁	S ₂	S ₃	S ₁	S ₂	S ₃	S ₁	S ₂	S ₃
SEm±	0.002	0.005	0.003	0.004	0.013	0.007	0.005	0.018	0.010
CD at 5 %		-	-	-		-	-	-	-

Table 4.8: Effect of brassinolide on relative growth rate ($\text{g}^{-1} \text{plant}^{-1} \text{day}^{-1}$) of rice genotypes at different growth stages

Varieties	Growth stage	Control	Brassinolide	Varietal Effect
R-1037-649-1-1	S ₁	0.0070	0.0081	0.0369
	S ₂	0.0021	0.0028	0.0187
	S ₃	0.0016	0.0023	0.0019
Danteshwari	S ₁	0.0056	0.0066	0.0318
	S ₂	0.0026	0.0022	0.0192
	S ₃	0.0101	0.0020	0.0017
R-979-1528-2-1	S ₁	0.0083	0.0089	0.0343
	S ₂	0.0035	0.0025	0.0250
	S ₃	0.0014	0.0021	0.0017
Indira Sugandhit Dhan	S ₁	0.0390	0.0061	0.0395
	S ₂	0.0145	0.0029	0.0208
	S ₃	0.0014	0.0015	0.0015
R-1182-167-2-157-1	S ₁	0.0505	0.0087	0.0450
	S ₂	0.0255	0.0029	0.0265
	S ₃	0.0011	0.0012	0.0012
Vasumati	S ₁	0.0420	0.0046	0.0410
	S ₂	0.0275	0.0027	0.0258
	S ₃	0.0013	0.0019	0.0016
R-1249-1196-2-1	S ₁	0.0325	0.0093	0.0357
	S ₂	0.0375	0.0035	0.0340
	S ₃	0.0017	0.0055	0.0036
R-548-89-6	S ₁	0.0340	0.0064	0.0295
	S ₂	0.0280	0.0031	0.0260
	S ₃	0.0017	0.0016	0.0017
R-1060-1674-1-1	S ₁	0.0340	0.0099	0.0428
	S ₂	0.0270	0.0014	0.0205
	S ₃	0.0012	0.0011	0.0011

Continued.....

Table 4.9: Effect of brassinolide on net assimilation rate ($\text{g}^{-1} \text{plant}^{-1} \text{day}^{-1}$) of rice genotypes at different growth stages

Varieties	Growth stage	Brassinolide	Control	Varietal Effect
R-1037-649-1-1	S ₁	0.0015	0.0024	0.0019
	S ₂	0.0009	0.0008	0.0009
Danteshwari	S ₁	0.0021	0.0711	0.0366
	S ₂	0.0013	0.0245	0.0129
R-979-1528-2-1	S ₁	0.0016	0.1195	0.0606
	S ₂	0.0010	0.0487	0.0249
Indira Sugandhit Dhan	S ₁	0.0777	0.0017	0.0397
	S ₂	0.1901	0.0011	0.0956
R-1182-167-2-157-1	S ₁	0.0747	0.0015	0.0381
	S ₂	0.0016	0.0062	0.0039
Vasumati	S ₁	0.0023	0.0022	0.0022
	S ₂	0.0023	0.0012	0.0018
R-1249-1196-2-1	S ₁	0.0018	0.0016	0.0017
	S ₂	0.0019	0.0015	0.0017
R-548-89-6	S ₁	0.0015	0.0007	0.0011
	S ₂	0.0013	0.0015	0.0014
R-1060-1674-1-1	S ₁	0.0098	0.0022	0.0066
	S ₂	0.0016	0.0006	0.0011
Safri-17	S ₁	0.0020	0.0055	0.0037
	S ₂	0.0009	0.0016	0.0013
Dubraj	S ₁	0.0012	0.0012	0.0012
	S ₂	0.0009	0.0021	0.0015
R-1072-360-1	S ₁	0.1353	0.0009	0.0681
	S ₂	0.0825	0.0015	0.0420
Treatment effect	S ₁	0.0259	0.0175	
	S ₂	0.0239	0.0076	

Stages	Varieties (V)		Treatments (T)		Interaction (V×T)	
	S ₁	S ₂	S ₁	S ₂	S ₁	S ₂
SEm±	0.010	0.011	0.024	0.028	0.034	0.039
CD at 5 %	-	-	-	-	-	-

Table 4.10: Effect of brassinolide on chlorophyll content (SPAD) of rice genotypes at different growth stages

Varieties	Growth stage	Control	Brassinolide	Varietal Effect
R-1037-649-1-1	S ₁	40.20	40.30	40.25
	S ₂	35.55	41.00	38.27
	S ₃	61.00	31.15	46.07
Danteshwari	S ₁	39.25	42.81	41.03
	S ₂	33.20	42.50	37.85
	S ₃	29.50	29.85	29.67
R-979-1528-2-1	S ₁	43.95	40.05	42.0
	S ₂	38.75	42.30	40.52
	S ₃	32.80	31.30	32.05
Indira Sugandhit Dhan	S ₁	39.80	38.0	38.90
	S ₂	42.05	36.60	39.32
	S ₃	28.15	26.40	27.27
R-1182-167-2-157-1	S ₁	41.90	38.45	40.17
	S ₂	39.95	36.40	38.17
	S ₃	30.10	31.40	30.75
Vasumati	S ₁	40.20	41.15	40.67
	S ₂	32.75	39.25	36.00
	S ₃	34.25	31.45	32.85
R-1249-1196-2-1	S ₁	38.20	37.70	37.95
	S ₂	42.40	34.85	38.62
	S ₃	32.60	31.55	32.07
R-548-89-6	S ₁	38.25	40.70	39.47
	S ₂	38.55	38.15	38.35
	S ₃	31.05	29.25	30.15
R-1060-1674-1-1	S ₁	39.90	39.95	39.92
	S ₂	36.45	43.05	39.75
	S ₃	29.10	26.65	27.87

Continued.....

Varieties	Growth stage	Control	Brassinolide	Varietal Effect
Safri-17	S ₁	36.95	41.60	39.27
	S ₂	35.20	42.65	38.92
	S ₃	31.40	28.30	29.75
Dubraj	S ₁	39.20	43.10	41.15
	S ₂	36.50	41.75	39.12
	S ₃	27.90	29.60	28.75
R-1072-360-1	S ₁	47.01	43.60	45.30
	S ₂	39.80	40.10	39.95
	S ₃	31.95	26.10	29.02
Treatment effect	S ₁	40.40	40.61	
	S ₂	37.59	39.88	
	S ₃	33.30	29.41	

Stages	Varieties (V)			Treatments (T)			Interaction (V×T)		
	S ₁	S ₂	S ₃	S ₁	S ₂	S ₃	S ₁	S ₂	S ₃
SEm±	1.50	1.63	4.79	0.61	0.66	1.95	2.12	2.30	6.78
CD at 5 %	-	-	-	-	1.94	-	-	6.74	-

Table 4.11: Effect of brassinolide on carbohydrate content (%) of rice genotypes at maturity stage

Varieties	Control	Brassinolide	Varietal Effect
R-1037-649-1-1	65.90	66.80	66.35
Danteshwari	69.00	69.80	69.40
R-979-1528-2-1	67.80	68.50	68.15
Indira Sugandhit Dhan	69.00	70.80	69.90
R-1182-167-2-157-1	64.00	65.00	64.50
Vasumati	68.00	69.80	68.90
R-1249-1196-2-1	60.80	62.00	61.40
R-548-89-6	65.60	68.00	66.80
R-1060-1674-1-1	61.90	64.00	62.95
Safri-17	71.00	72.72	71.85
Dubraj	70.90	71.90	71.40
R-1072-360-1	62.70	64.00	63.35
Treatment effect	66.38	67.77	
	Variety (V)	Treatment (T)	Interaction (V×T)
SEm±	0.05	0.12	0.17
CD at 5 %	0.14	0.36	0.51

Table 4.12: Effect of brassinolide on number of productive tillers plant⁻¹ of rice genotypes at maturity stage

Varieties	Control	Brassinolide	Varietal Effect
R-1037-649-1-1	15.95	17.65	16.80
Danteshwari	17.30	16.80	17.05
R-979-1528-2-1	15.65	16.95	16.30
Indira Sugandhit Dhan	15.30	16.65	15.97
R-1182-167-2-157-1	15.50	16.80	16.15
Vasumati	15.30	11.45	13.37
R-1249-1196-2-1	15.50	16.50	15.82
R-548-89-6	16.45	16.45	16.45
R-1060-1674-1-1	15.80	15.50	15.65
Safri-17	10.00	10.98	10.49
Dubraj	6.50	6.65	6.57
R-1072-360-1	15.80	16.66	16.23
Treatment effect	14.55	14.92	
	Variety (V)	Treatment (T)	Interaction (V×T)
SEm±	0.29	0.71	1.01
CD at 5 %	-	2.09	-

Table 4.13: Effect of brassinolide on panicle length (cm) of rice genotypes at maturity stage

Varieties	Control	Brassinolide	Varietal Effect
R-1037-649-1-1	28.68	17.49	23.08
Danteshwari	23.20	27.50	25.35
R-979-1528-2-1	24.98	25.38	25.18
Indira Sugandhit Dhan	23.63	24.99	24.31
R-1182-167-2-157-1	26.05	28.10	27.07
Vasumati	22.50	25.65	24.07
R-1249-1196-2-1	25.65	24.13	24.89
R-548-89-6	25.33	26.03	25.68
R-1060-1674-1-1	26.43	22.71	24.57
Safri-17	26.60	26.08	26.34
Dubraj	27.06	23.45	25.25
R-1072-360-1	23.95	36.87	30.41
Treatment effect	25.33	25.70	
	Variety (T)	Treatment (T)	Interaction (V×T)
SEm±	1.97	0.80	2.78
CD at 5 %	-	-	-

Table 4.14: Effect of brassinolide on panicle weight (g) of rice genotypes at maturity stage

Varieties	Control	Brassinolide	Varietal Effect
R-1037-649-1-1	1.84	1.85	1.84
Danteshwari	1.99	1.76	1.87
R-979-1528-2-1	1.79	1.60	1.69
Indira Sugandhit Dhan	1.40	1.66	1.53
R-1182-167-2-157-1	2.53	2.12	2.33
Vasumati	1.44	1.98	1.71
R-1249-1196-2-1	2.55	2.24	2.40
R-548-89-6	2.27	2.39	2.30
R-1060-1674-1-1	1.62	2.14	1.88
Safri-17	2.03	1.47	1.75
Dubraj	1.38	1.71	1.55
R-1072-360-1	2.35	2.55	2.45
Treatment effect	1.93	1.96	
	Variety (V)	Treatment (T)	Interaction (V×T)
SEm±	0.33	0.13	0.48
CD at 5 %	-	-	-

Table 4.15: Effect of brassinolide on number of filled grains of rice genotypes at maturity stage

Varieties	Control	Brassinolide	Varietal Effect
R-1037-649-1-1	115.49	121.83	118.66
Danteshwari	135.99	107.83	121.91
R-979-1528-2-1	125.83	120.49	123.16
Indira Sugandhit Dhan	128.66	131.696	130.16
R-1182-167-2-157-1	144.16	133.49	138.83
Vasumati	116.33	129.99	123.14
R-1249-1196-2-1	141.49	144.33	142.91
R-548-89-6	149.16	137.16	143.16
R-1060-1674-1-1	107.66	104.0	105.83
Safri-17	149.33	97.16	123.24
Dubraj	105.16	87.99	96.57
R-1072-360-1	113.16	144.99	129.07
Treatment effect	127.70	121.74	
	Variety (V)	Treatment (T)	Interaction (V×T)
SEm±	16.76	6.84	23.70
CD at 5 %	-	-	-

Table 4.16: Effect of brassinolide on number of unfilled grains of rice genotypes at maturity stage

Varieties	Control	Brassinolide	Varietal Effect
R-1037-649-1-1	65.66	83.49	74.58
Danteshwari	58.16	95.02	76.59
R-979-1528-2-1	41.49	42.49	41.99
Indira Sugandhit Dhan	62.66	77.16	69.91
R-1182-167-2-157-1	71.33	70.16	70.74
Vasumati	50.16	84.49	67.33
R-1249-1196-2-1	53.50	52.50	53.0
R-548-89-6	94.99	58.50	76.74
R-1060-1674-1-1	52.99	38.49	45.74
Safri-17	90.16	110.49	100.33
Dubraj	56.49	114.83	85.66
R-1072-360-1	73.83	61.49	67.66
Treatment Effect	4.28	74.09	
	Variety (V)	Treatment (T)	Interaction (V×T)
SEm±	13.01	5.31	18.41
CD at 5 %	-	-	-

Table 4.17: Effect of brassinolide on grain yield plot⁻¹ (g) of rice genotypes at maturity stage

Varieties	Control	Brassinolide	Varietal Effect
R-1037-649-1-1	2250.00	2300.00	2275.00
Danteshwari	2450.00	2505.00	2477.50
R-979-1528-2-1	2350.00	2350.00	2350.00
Indira Sugandhit Dhan	2050.00	2125.00	2087.00
R-1182-167-2-157-1	2550.00	2600.00	2575.00
Vasumati	2050.00	2125.00	2087.50
R-1249-1196-2-1	2900.00	2825.00	2887.50
R-548-89-6	2150.00	2200.00	2175.00
R-1060-1674-1-1	2450.00	2525.00	2487.50
Safri-17	2550.00	2625.00	2587.50
Dubraj	1950.00	2000.00	1975.00
R-1072-360-1	2425.00	2475.00	2450.00
Treatment effect	2343.75	2392.08	
	Variety (V)	Treatment (T)	Interaction (V×T)
SEm±	7.54	18.47	26.12
CD at 5 %	22.06	54.04	-

Table 4.18: Effect of brassinolide on harvest index (%) of rice genotypes at maturity stage

Varieties	Control	Brassinolide	Varietal Effect
R-1037-649-1-1	23.79	29.79	26.79
Danteshwari	37.34	26.42	31.88
R-979-1528-2-1	31.45	35.85	33.65
Indira Sugandhit Dhan	23.75	29.82	26.78
R-1182-167-2-157-1	29.97	32.79	31.38
Vasumati	36.58	35.59	36.09
R-1249-1196-2-1	47.30	42.02	44.66
R-548-89-6	22.90	26.03	24.46
R-1060-1674-1-1	28.90	25.86	27.38
Safri-17	37.12	32.81	34.97
Dubraj	40.03	35.47	37.75
R-1072-360-1	28.34	29.75	29.05
Treatment effect	32.29	31.85	
	Variety (V)	Treatment (T)	Interaction (V×T)
SEm±	0.44	1.08	1.53
CD at 5 %	-	3.17	4.48

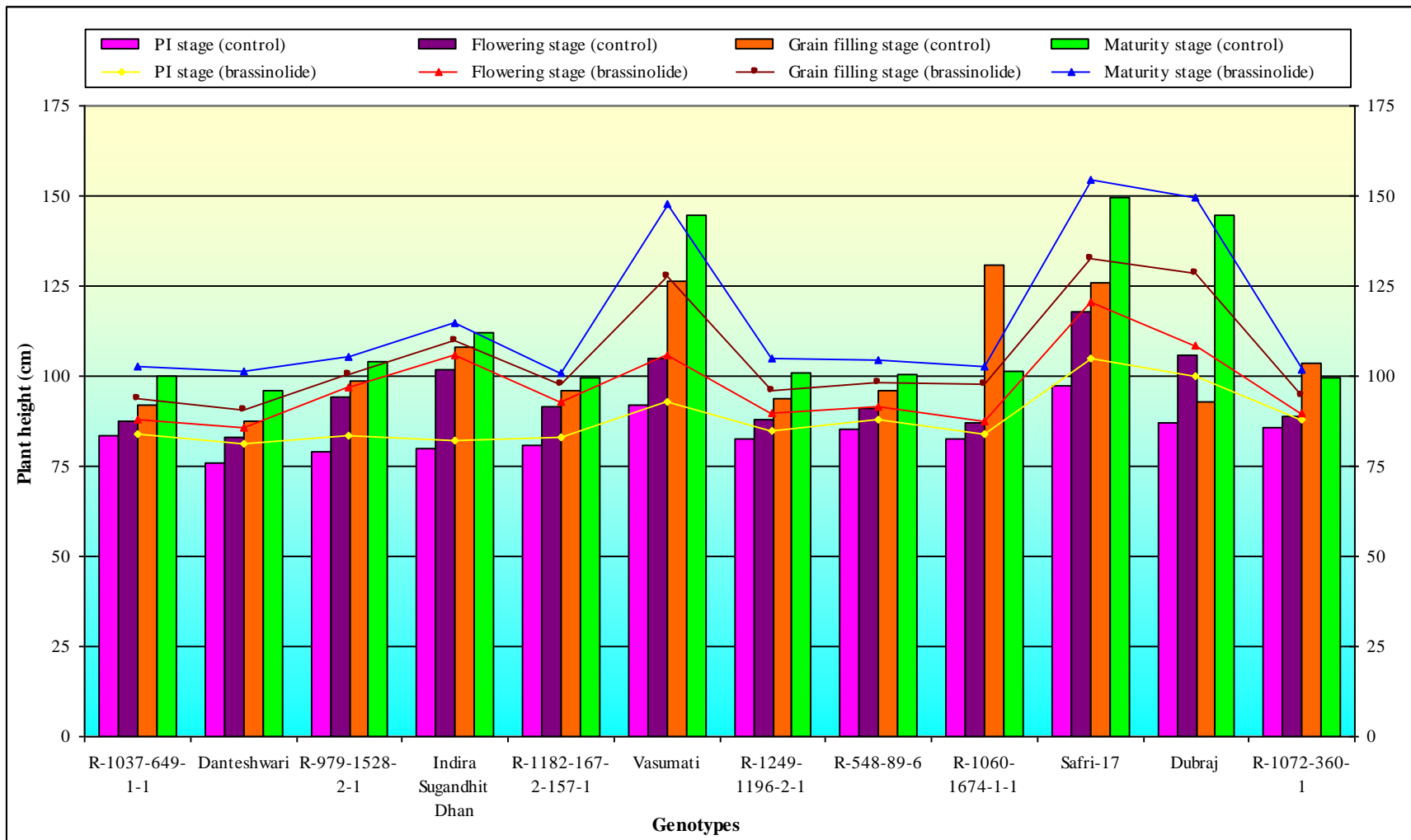


Fig. 4.1: Variation in foliar spray of brassinolide on plant height (cm) at different growth stages of rice genotypes

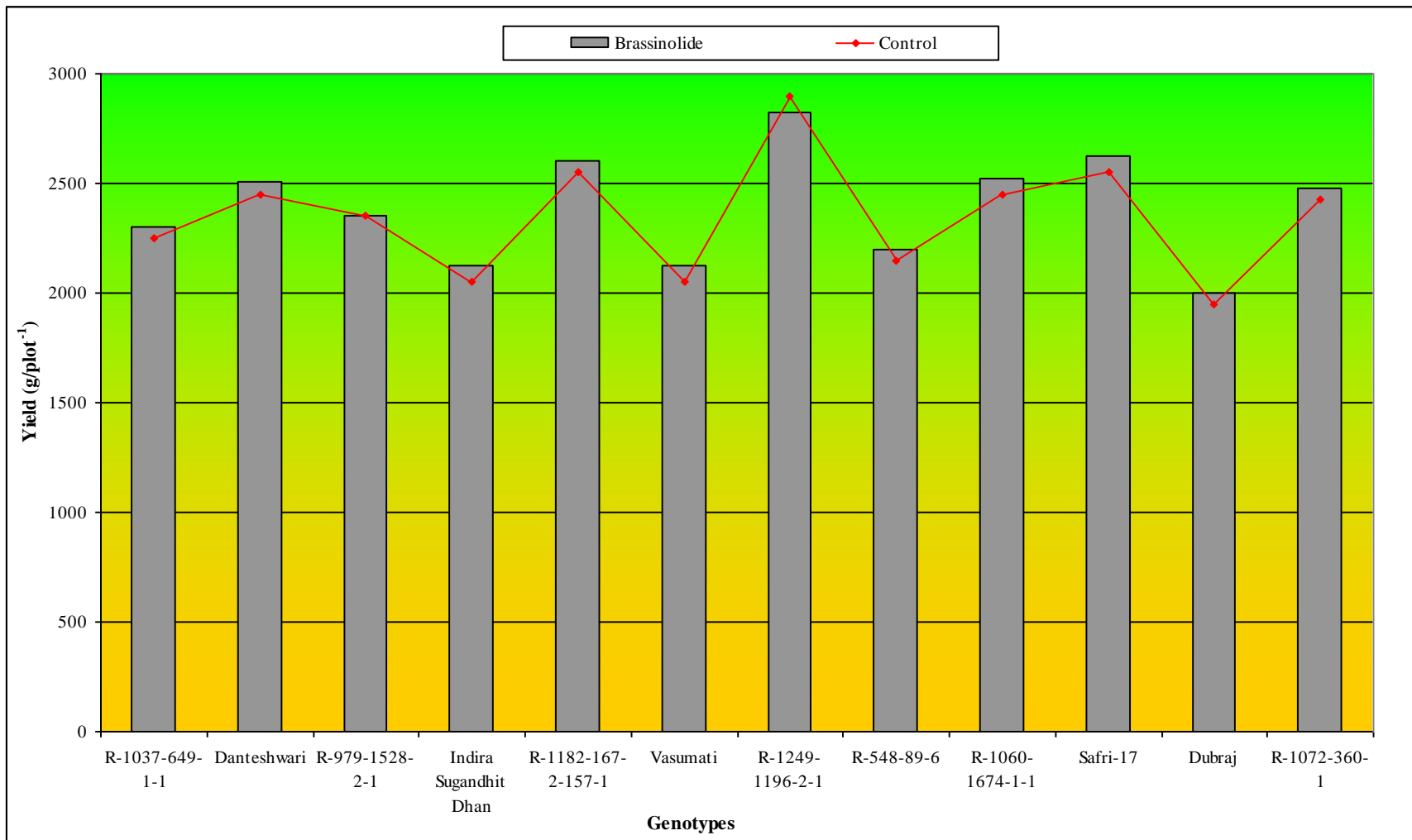


Fig. 4.6: Variation in foliar spray of brassinolide on grain yield (g/plot⁻¹) of rice genotypes

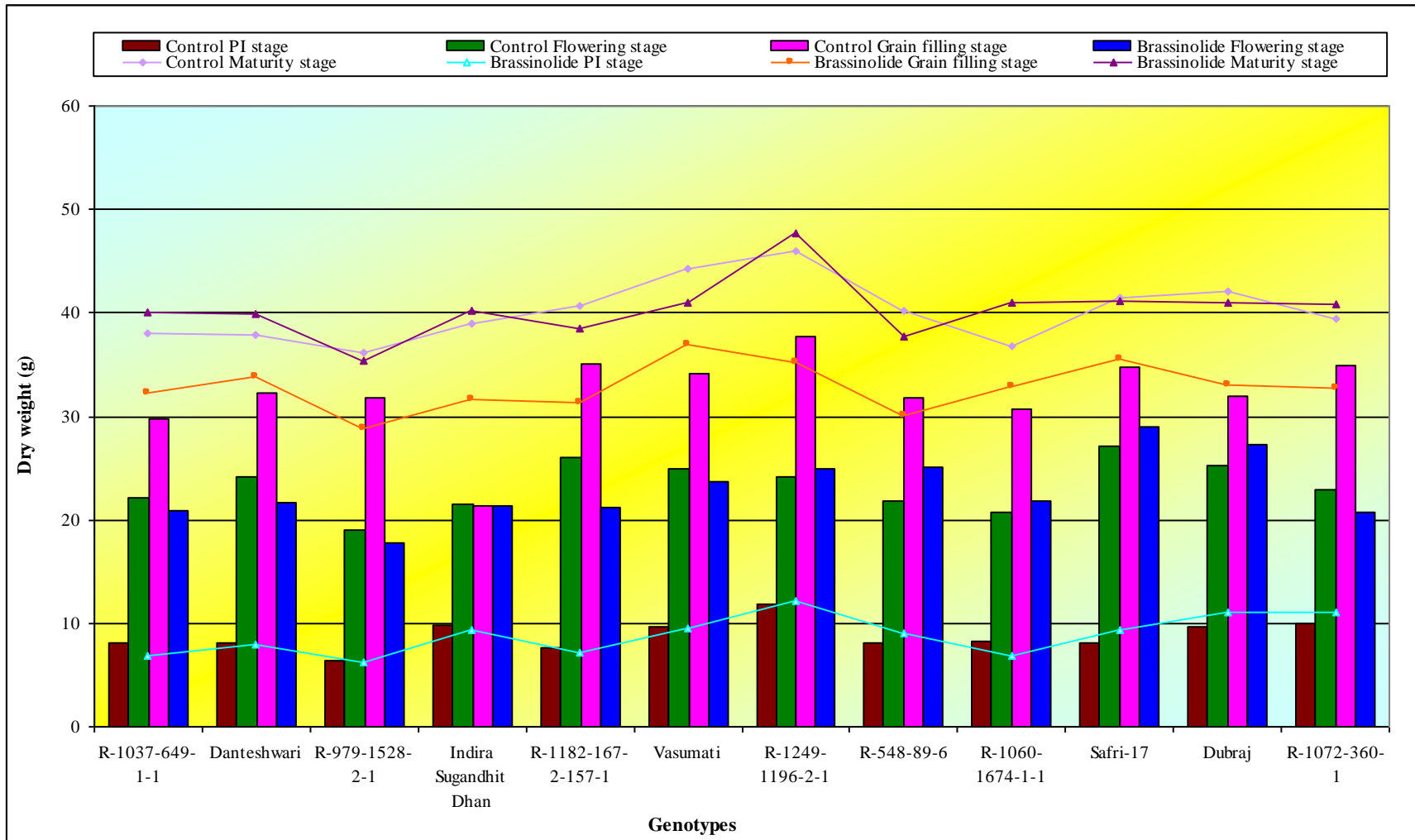


Fig. 4.3: Variation in foliar spray of brassinolide on dry weight (g) at different growth stages of rice genotypes

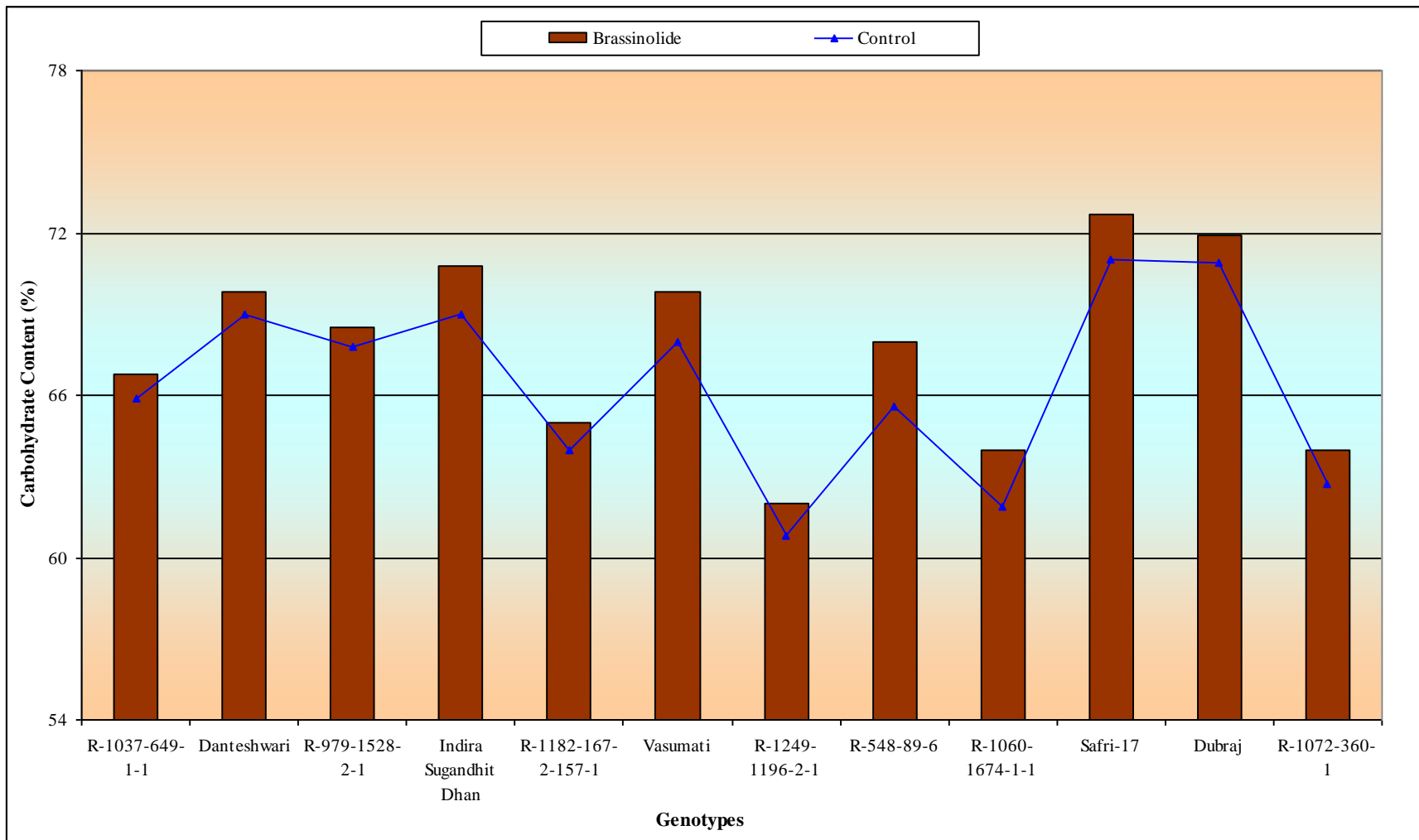


Fig. 4.5: Variation in foliar spray of brassinolide on carbohydrate content (%) of rice genotypes

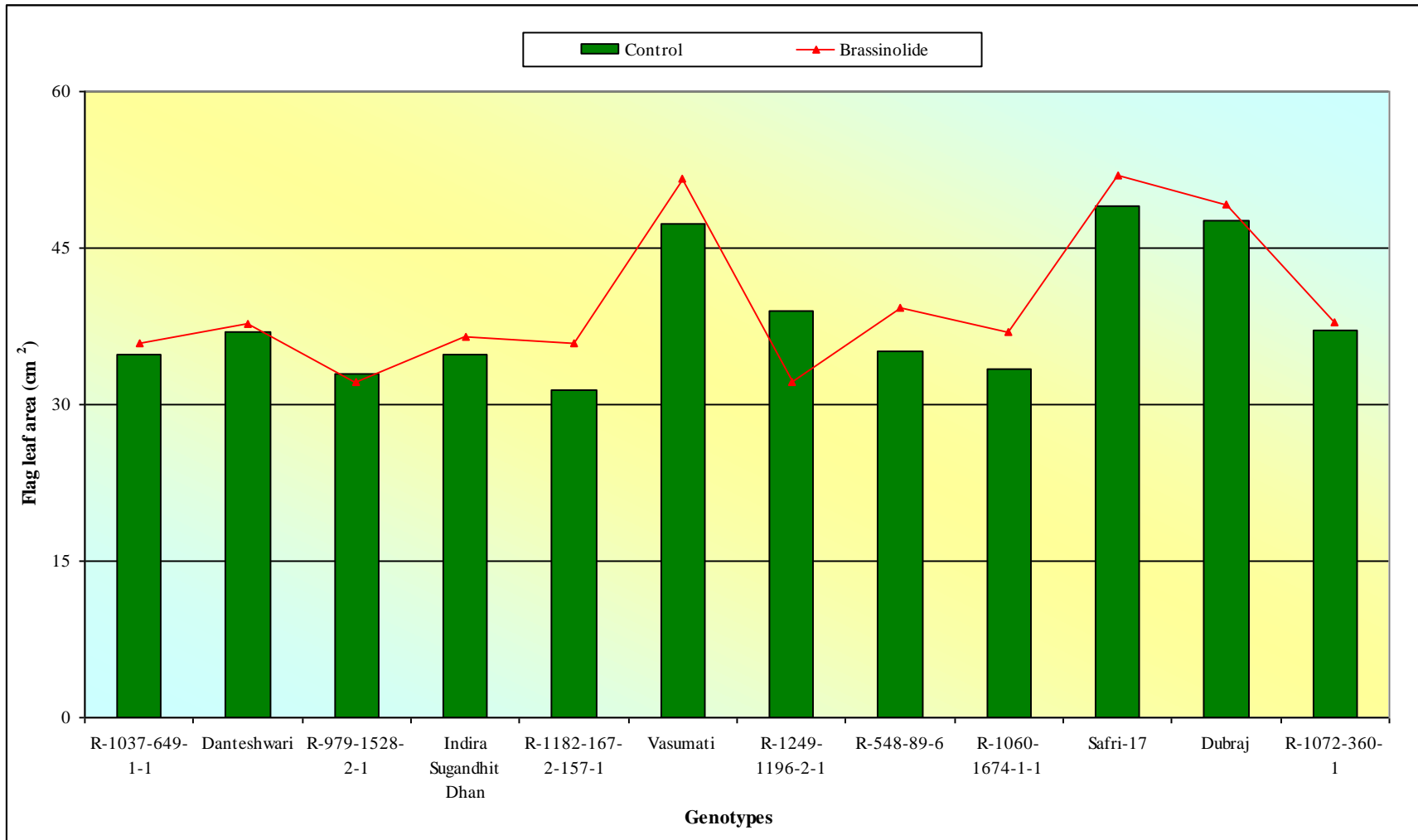


Fig. 4.2: Variation in foliar spray of brassinolide on flag leaf area (cm²) of rice genotypes at flowering stage

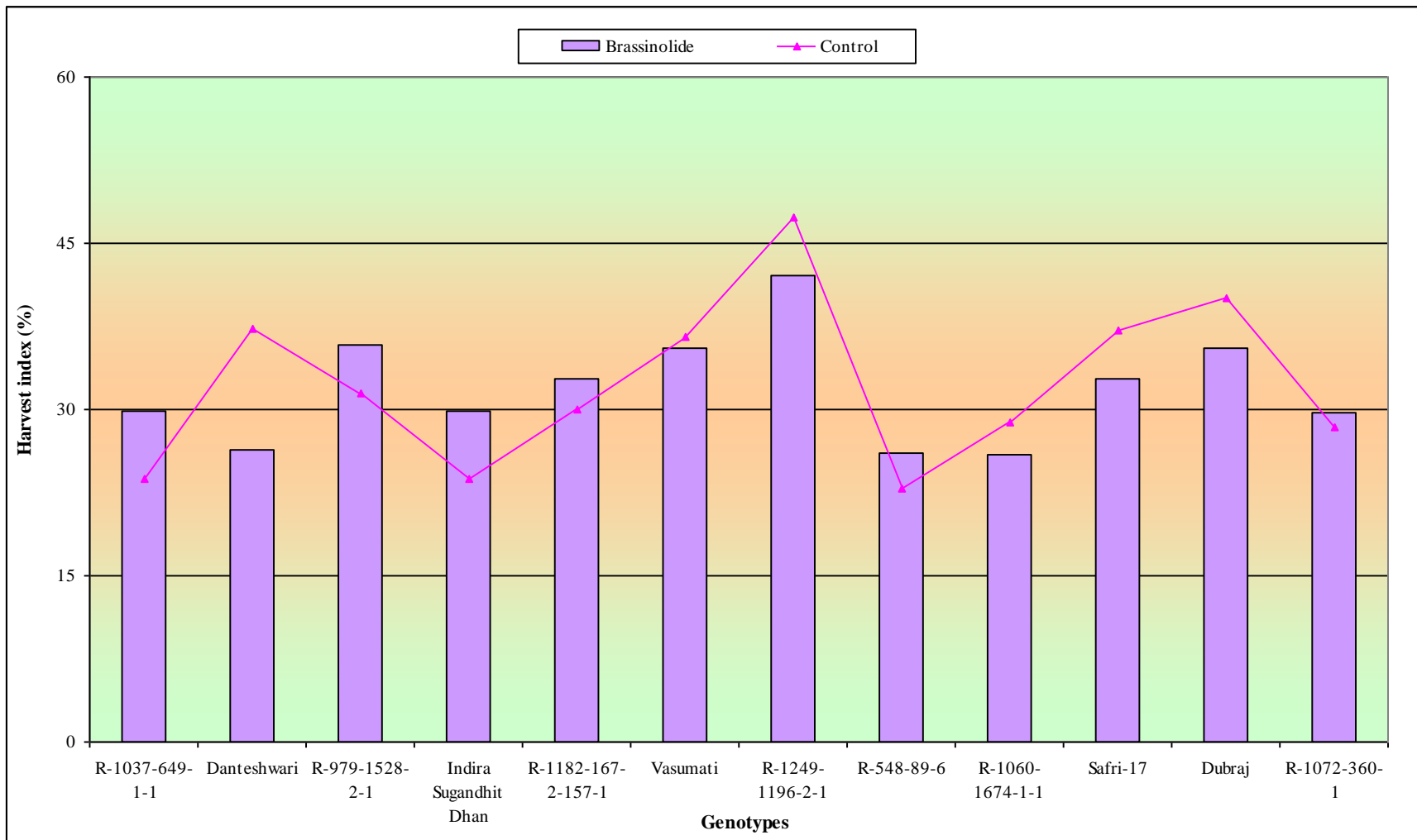


Fig. 4.7: Variation in foliar spray of brassinolide on harvest index (%) of rice genotypes

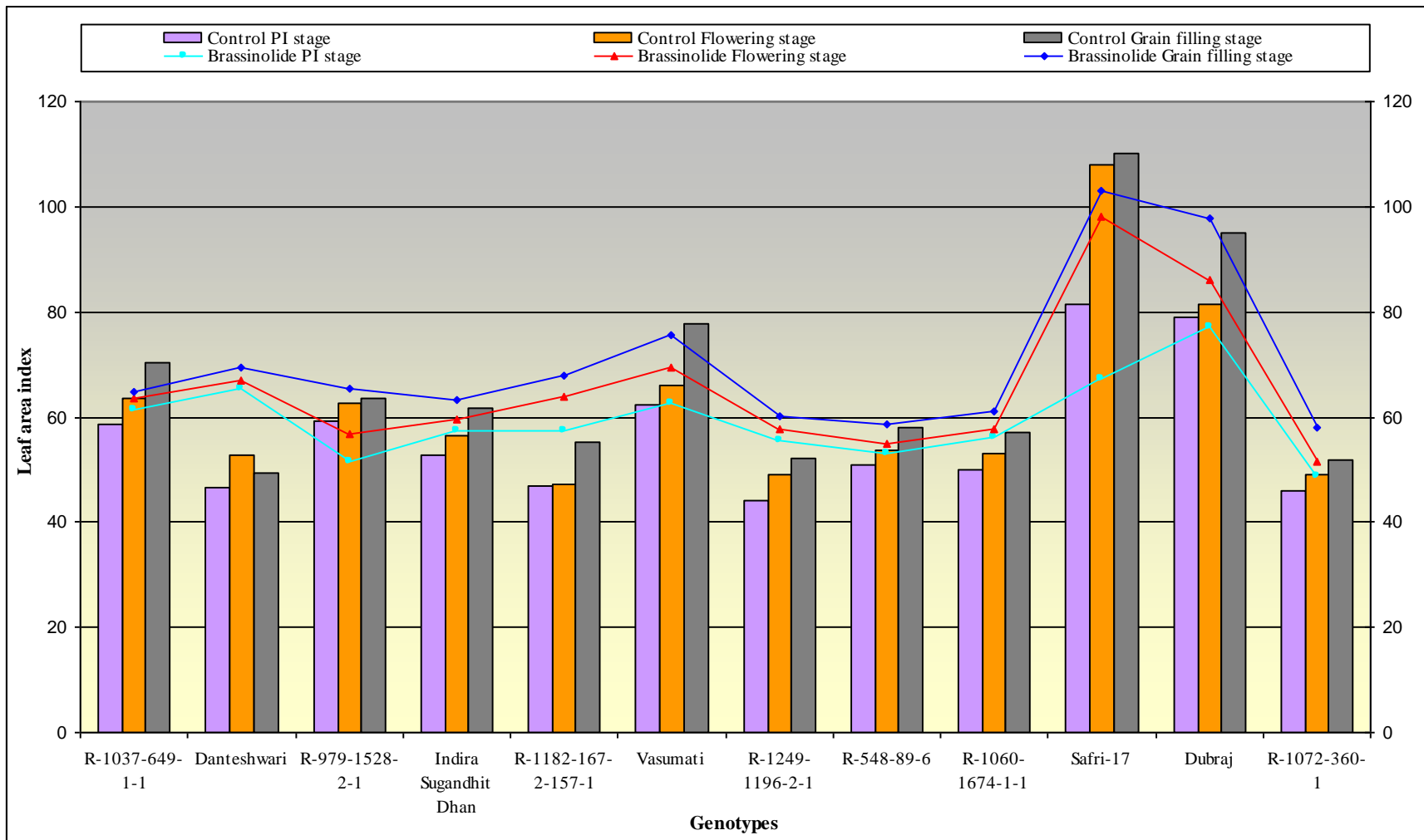


Fig. 4.4: Variation in foliar spray of brassinolide on leaf area index at different growth stages of rice genotypes

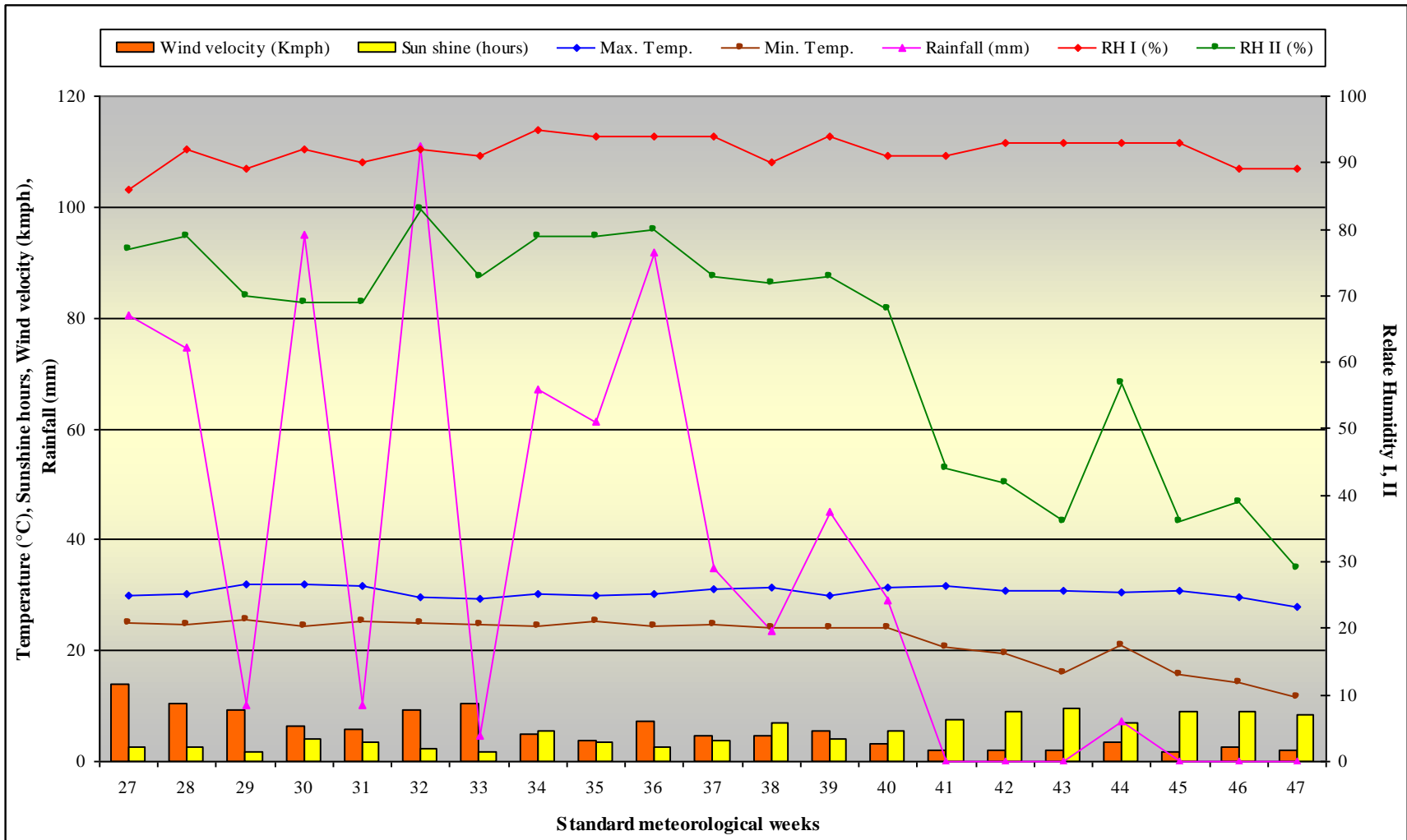


Fig. 3.1: Weekly meteorological observations recorded during the crop season

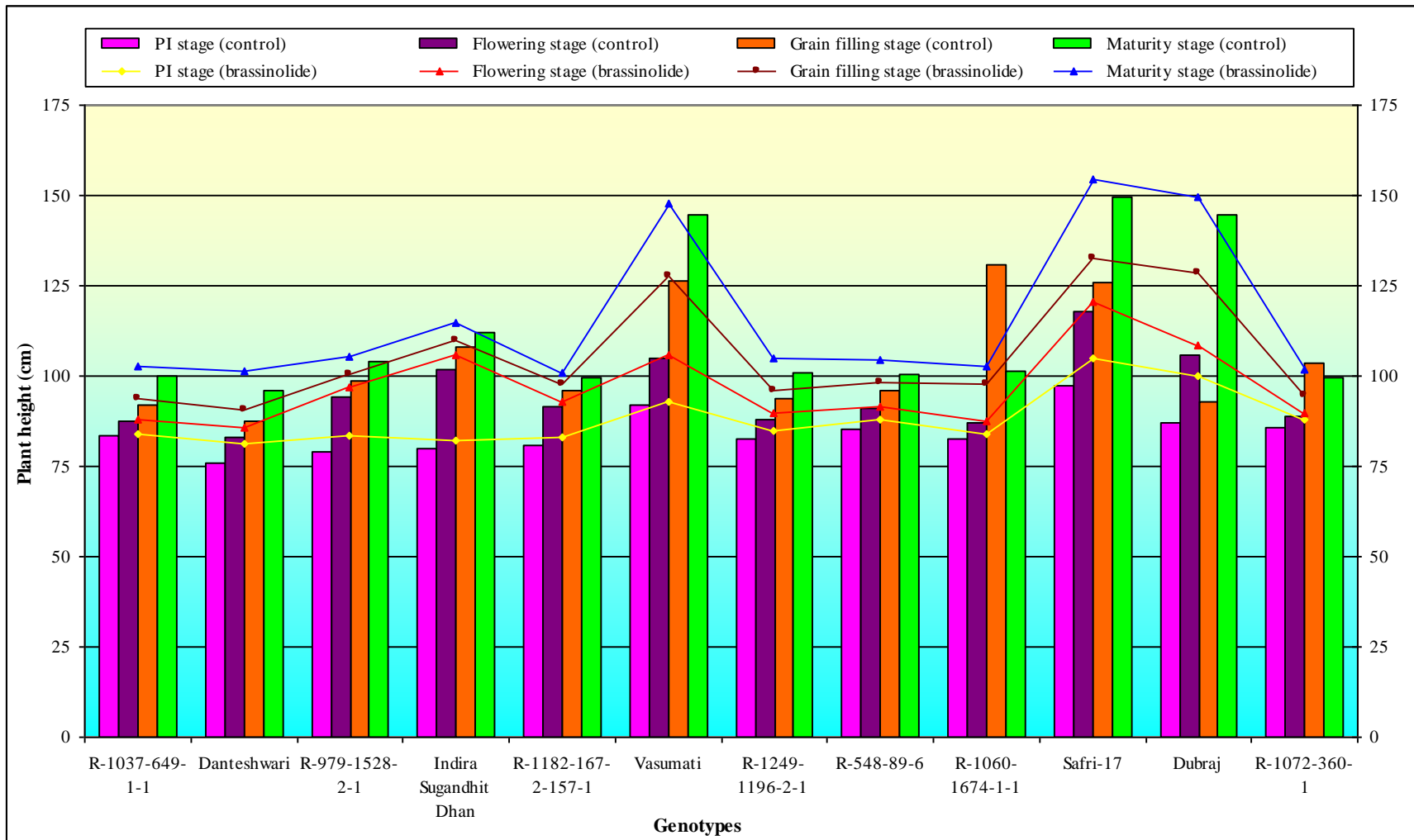


Fig. 4.1: Variation in foliar spray of brassinolide on plant height (cm) at different growth stages of rice genotypes

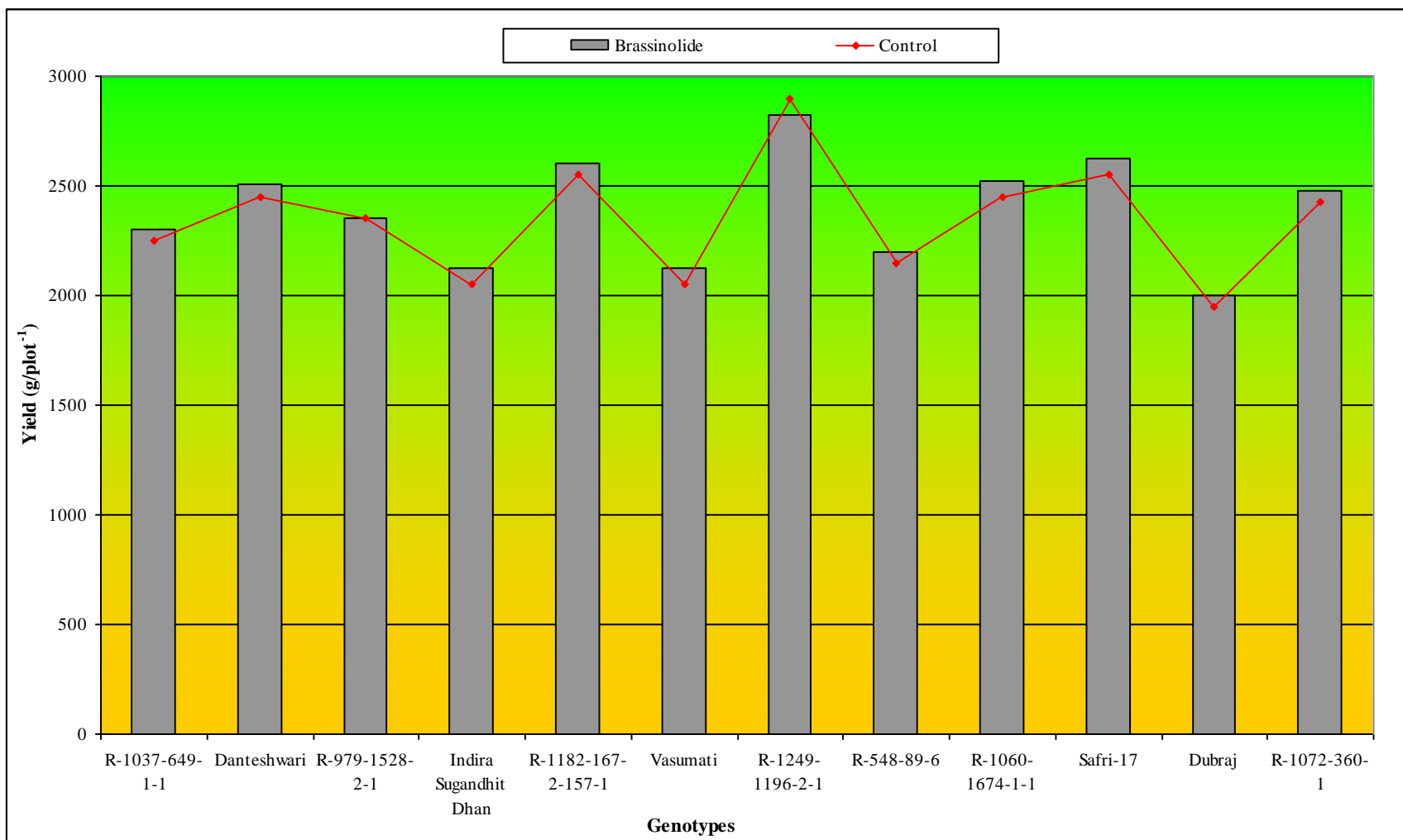


Fig. 4.6: Variation in foliar spray of brassinolide on grain yield (g/plot⁻¹) of rice genotypes

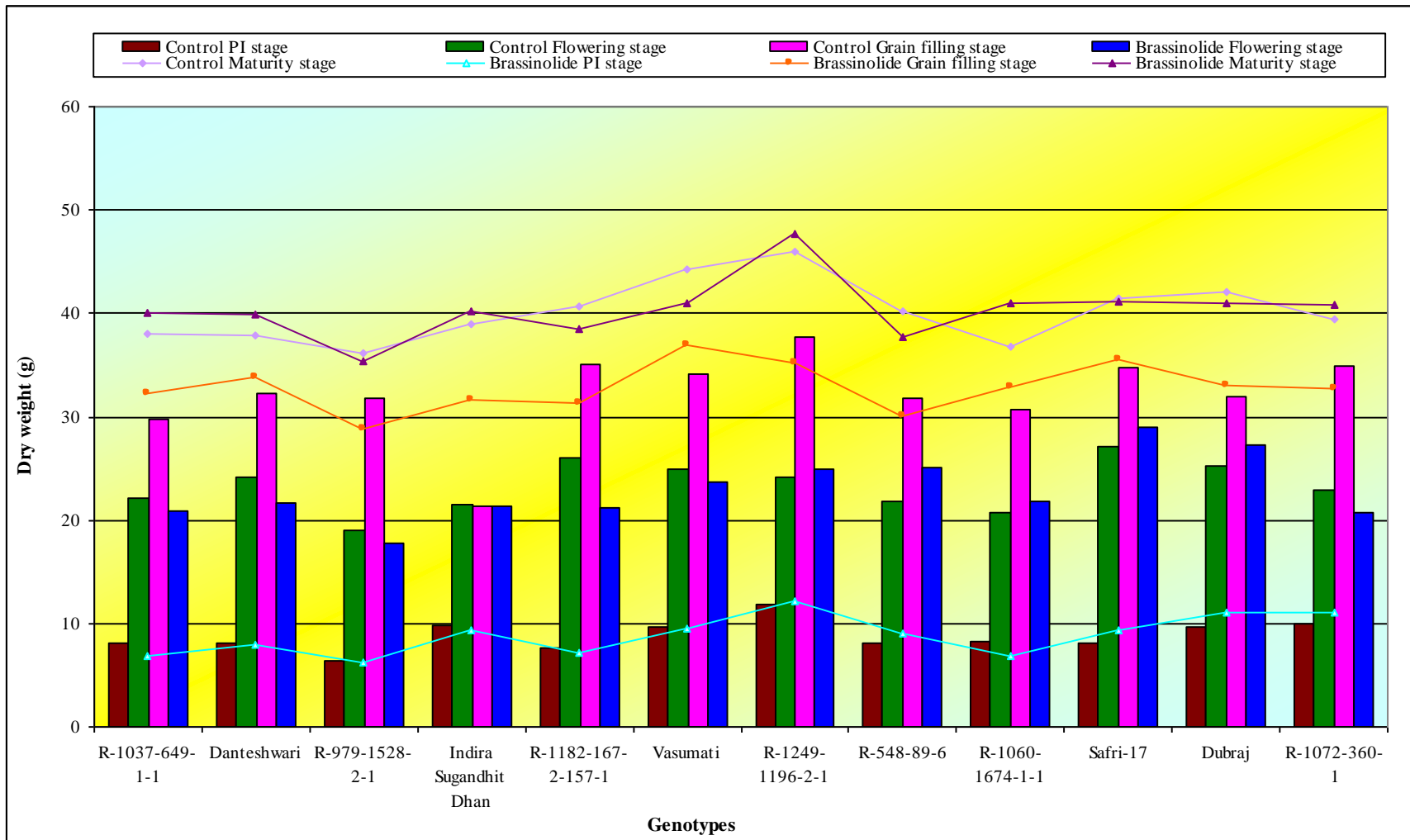


Fig. 4.3: Variation in foliar spray of brassinolide on dry weight (g) at different growth stages of rice genotypes

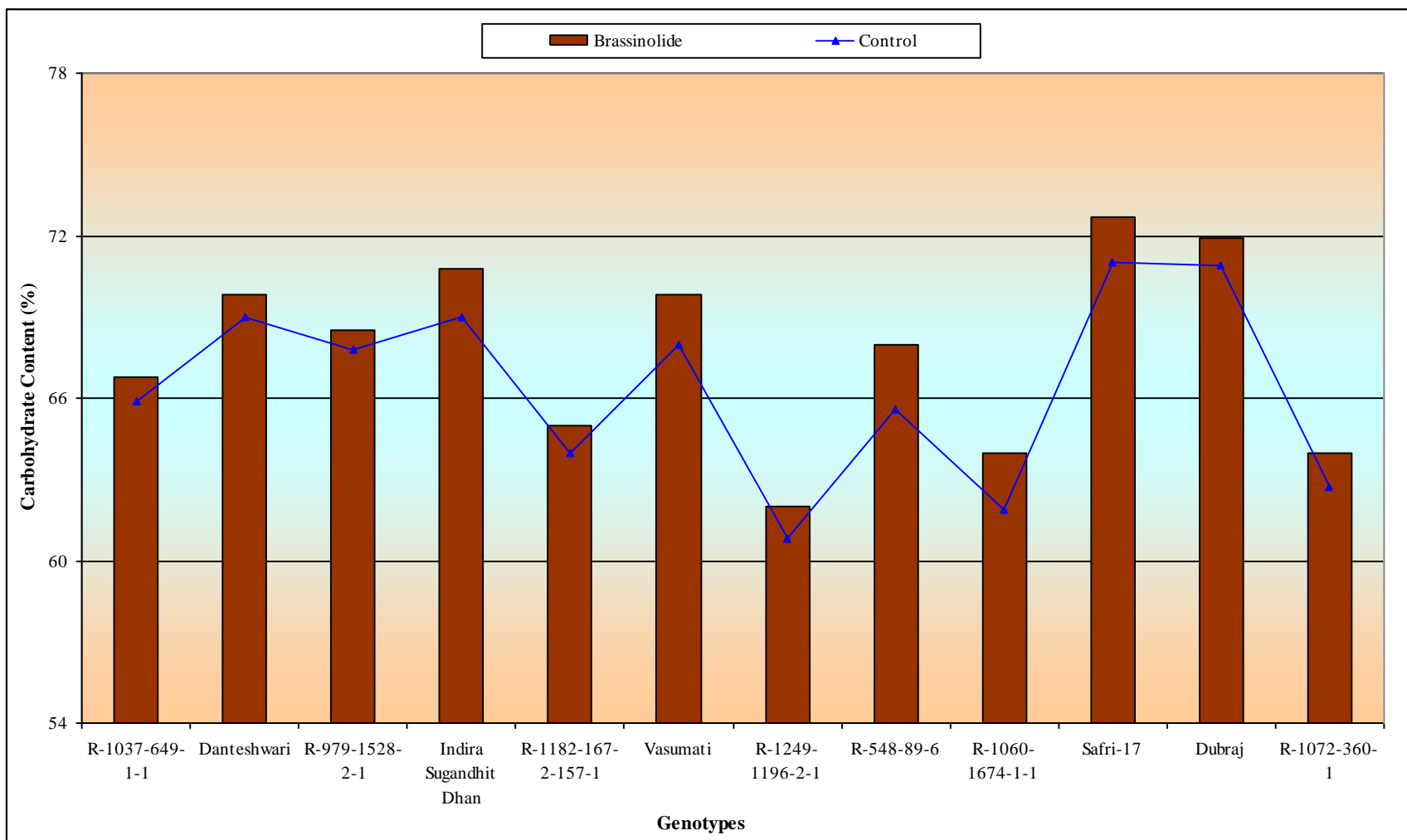


Fig. 4.5: Variation in foliar spray of brassinolide on carbohydrate content (%) of rice genotypes

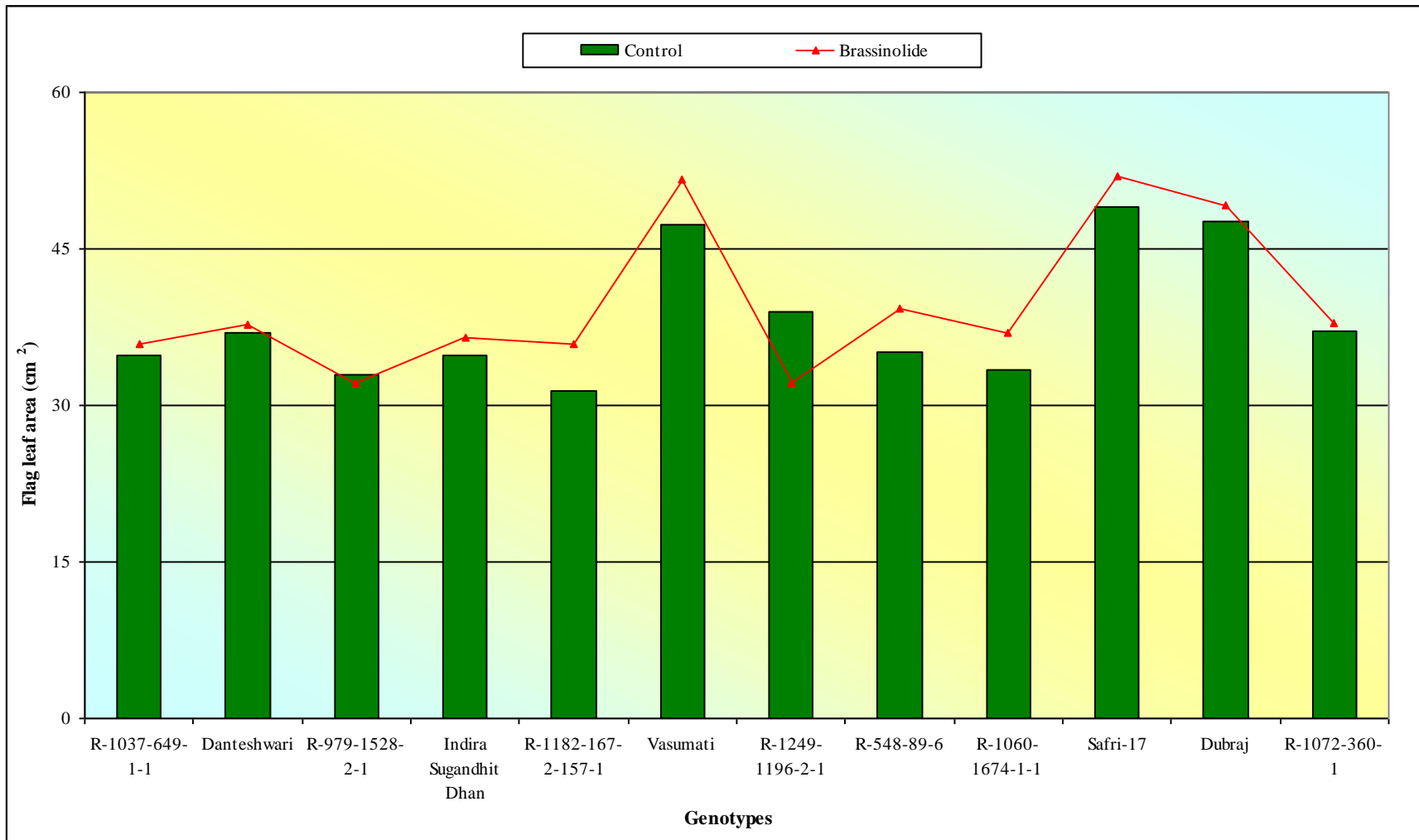


Fig. 4.2: Variation in foliar spray of brassinolide on flag leaf area (cm²) of rice genotypes at flowering stage

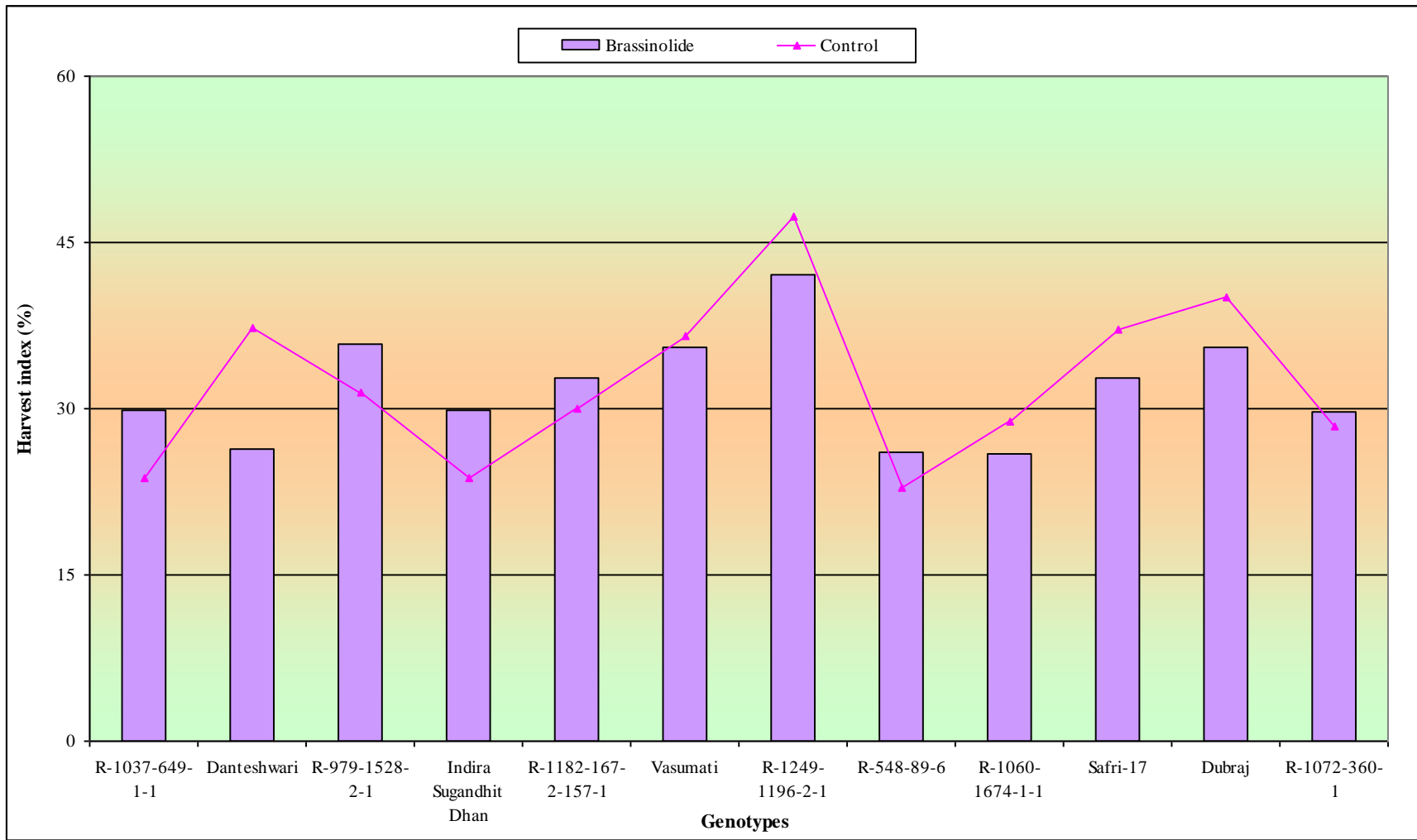


Fig. 4.7: Variation in foliar spray of brassinolide on harvest index (%) of rice genotypes

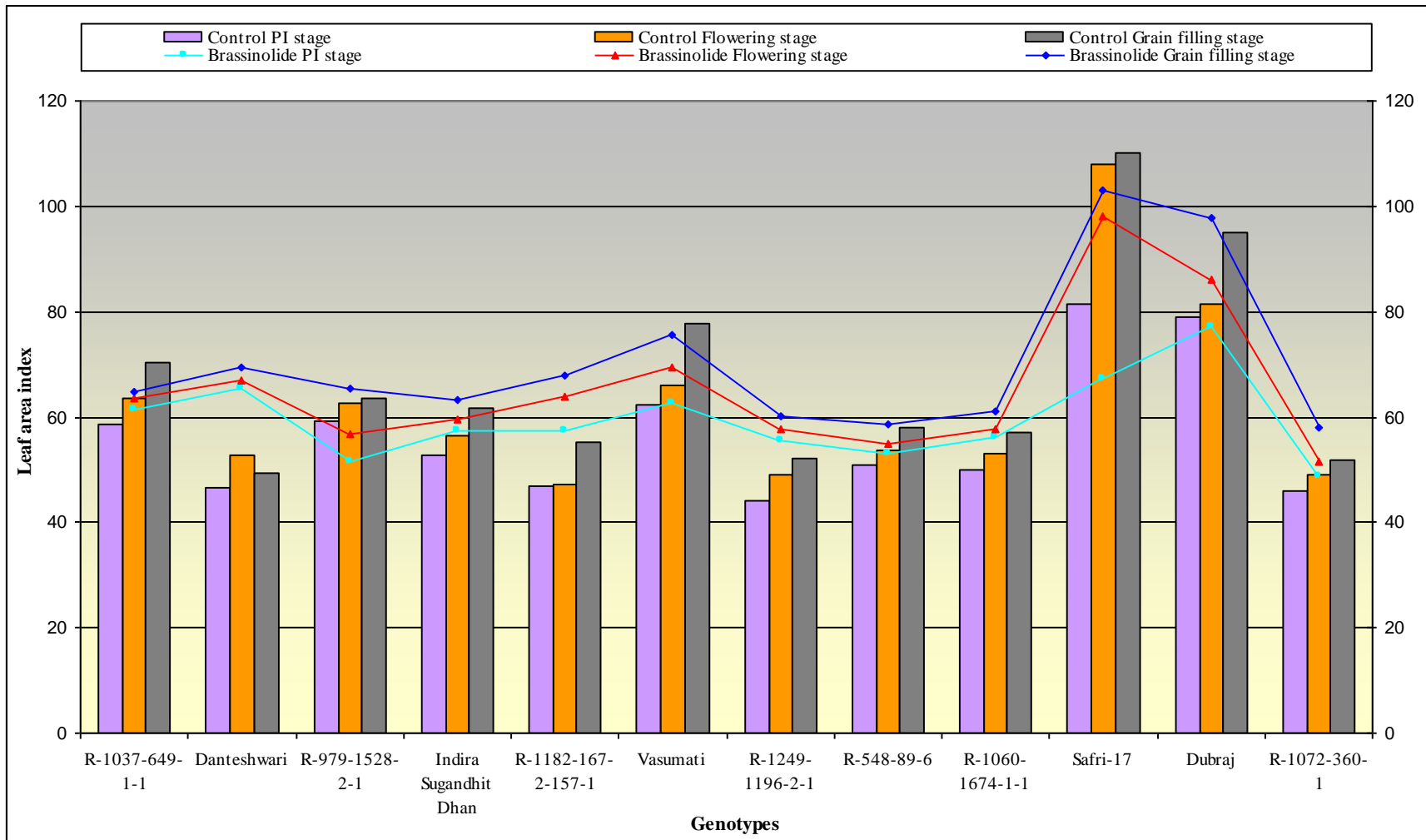


Fig. 4.4: Variation in foliar spray of brassinolide on leaf area index at different growth stages of rice genotypes

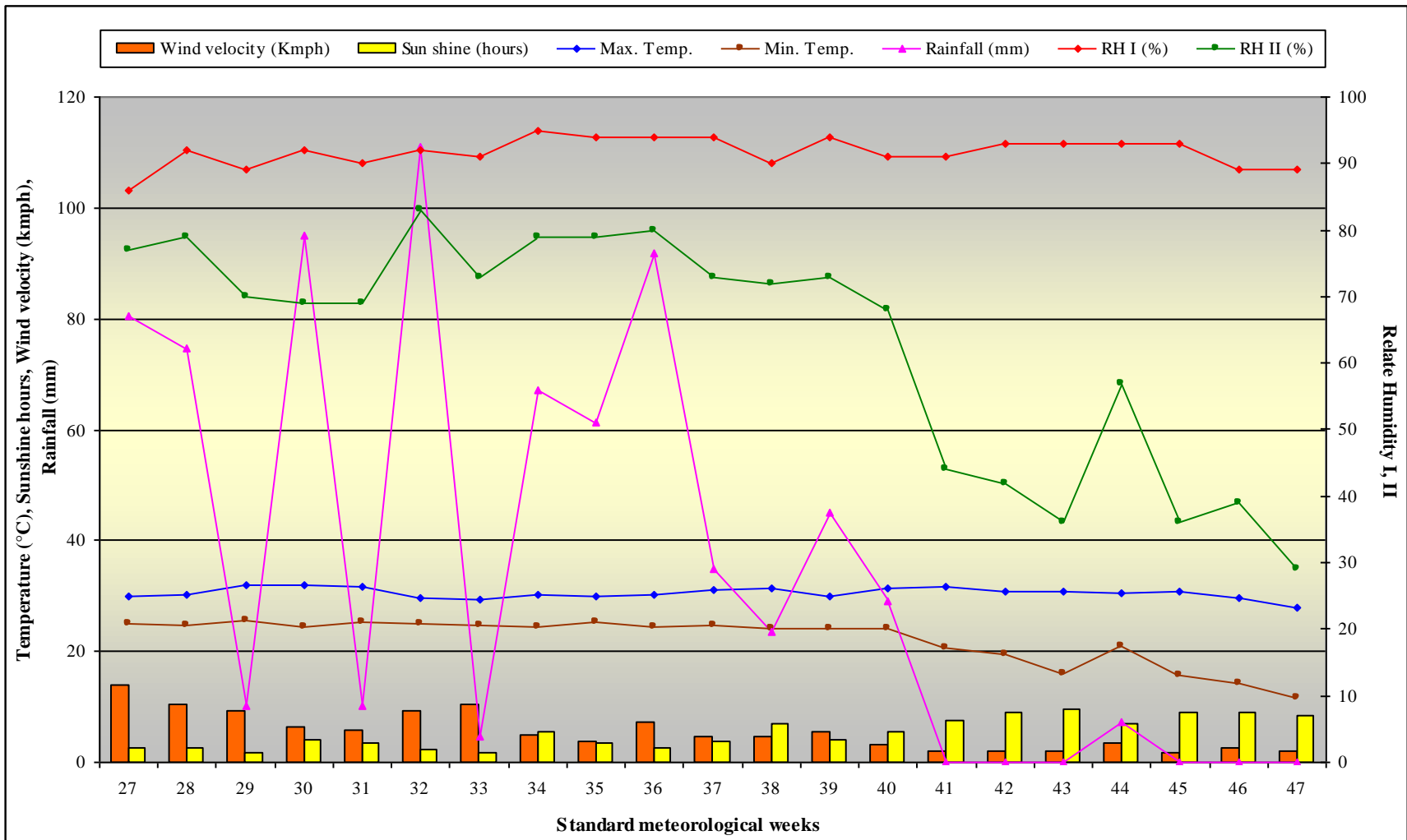


Fig. 3.1: Weekly meteorological observations recorded during the crop season



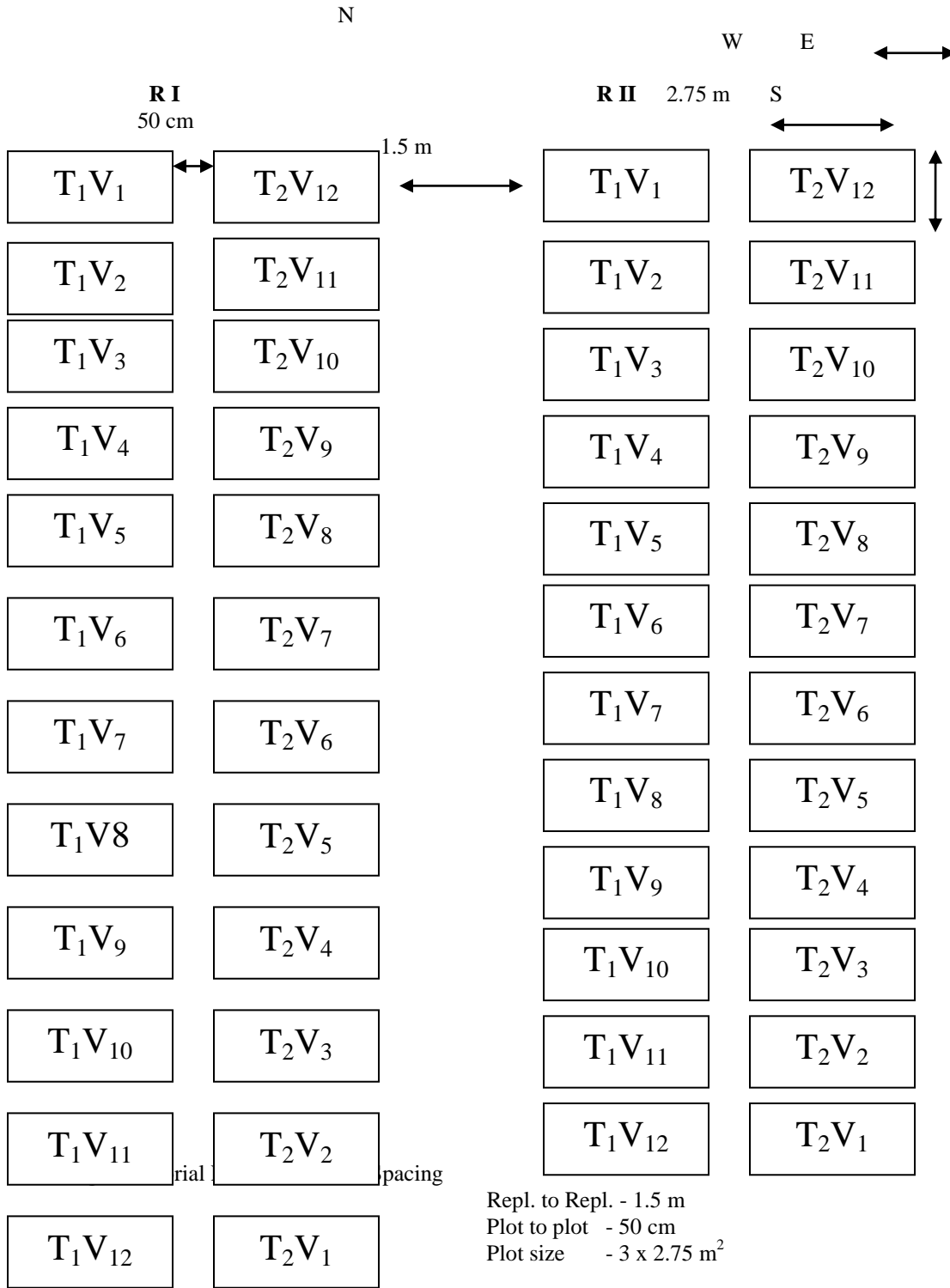


Fig. 3.2 Layout plan of experiment