guard cells and pollen grains. Cytological studies confirmed that the plants are complete, nonchimeral tetraploids.

The cytology of the diploid clone is similar to that reported earlier[1]. It has a somatic chromosome number of $2n = 22$. Quadrivalents indicating structural hybridity for interchanges, and bridges and fragments, characteristic of inversion heterozygotes have been found at meiosis. The diploid showed 87% aborted pollen. The tetraploid had $2n = 44$ chromosomes in root tip cells (figure 2). Meiosis in PMCs showed a high frequency of quadrivalents at first metaphase (figure 3). Associations of more than four chromosomes, up to eight, have also been observed frequently. At first anaphase, the tetraploid showed one or more aberrations including bridges and fragments and laggards. Single chromatid bridges with one associated fragment and double chromatid bridges with two fragments have been observed as in the diploid. However, the pollen was 85% stainable and well-filled, and larger than in the diploid.

The present study has opened up possibilities of improvement of this crop in which the lack of seed set had limited the scope of conventional plant breeding methods to selection from a few local and exotic clones[2]. The tetraploids are more vigorous than the diploids and there is considerable promise of improvement in yield. They can directly be utilized as new improved varieties by vegetative propagation.

The author is thankful to Prof. C. A. Ninan for suggestions and encouragement.

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SELECTION OF BENGAL GRAM (*CICER ARIETINUM* L.) MUTANTS FOR LATE SOWN CONDITIONS IN NORTH INDIA

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In north India, particularly in Punjab, Haryana and Western U.P., the cropping pattern has considerably changed in the past few years. Rice is now a dominant kharif crop in these areas, which is often followed by wheat. Both crops together make the cropping pattern intensive in respect of fertilizers, water and other inputs. A leguminous crop after rice could provide a balance in this new pattern. Bengal gram also known as chickpea (*Cicer arietinum*) could be a desirable legume but this crop is traditionally sown in the later half of October.

Studies on the growth and reproductive behaviour of Bengal gram showed that early flowering provided no significant advantage if irrigation is available[1]. Therefore, the genotypes which required almost the same time for flowering even after delayed sowing could be successful. With this objective, a progamme to induce mutations in an otherwise good and acceptable variety JG-62 was started in November 1975. Seeds (500) of JG-62 were soaked in distilled water for 6 hr and were subsequently treated with 0·03% EMS for 16 hr. Twentysix plants which set fruits were collected individually. All seeds from each plant were sown in the last week of November 1976. The distance between rows and between plants was 50 cm and 25 cm respectively. More than 400 plants reached maturity. On the basis of the date of flowering, plant structure and seed characters 200 plants were selected. In 1977, seeds from each plant were put in one row of 4 metre length. This year, leaf characteristics, flowering habit, nodulation at flowering, podding intensity and seed characters were used as selection criteria to reduce the number to 84 variants. In 1978, 28 variants and the parent were sown in both normal (last week of Oct.) and late (last week of Nov.) sowings to assess the performance of variants as a late sown crop. Data on the number of days to flower were recorded. At the time of harvest, total dry matter m^{-2}, grain yield m^{-2}, nitrogen content of grains, 1000 grain weight and harvest index were recorded. Irrigation was given when required.

The average dry matter (DM) m^{-2} of 29 genotypes including 28 variants and the parent was 925 g/m^{-2} in normal (early) sowing and 1070 g/m^{-2} in late sowing (figure 1). However, the dry matter produced by genotypes ranged from 600 to 1300 g^{-2} in early sowing and from 710 to 1800 gm^{-2} in late sowing. Therefore, it was clear that the same or even more dry matter could be produced in a late sown crop as compared to a normal sown crop, provided that irrigation was given. Nonetheless, it is important to note that superior variants could be obtained as compared to parent in respect of dry matter. At present it is difficult to say whether increase in dry matter occurred because of increase in photosynthesis rate or for some other reason.

The parent took 64 and 82 days for the first flower to open in early and late sowings respectively. The average for 28 variants was 68 days to flower in early sowing and 82 days to flower in late sowing. Amongst the variants 11 flowered earlier than the parent, 7 flowered along with the parent while 10 took more time to flower as compared to the parent in late sowing

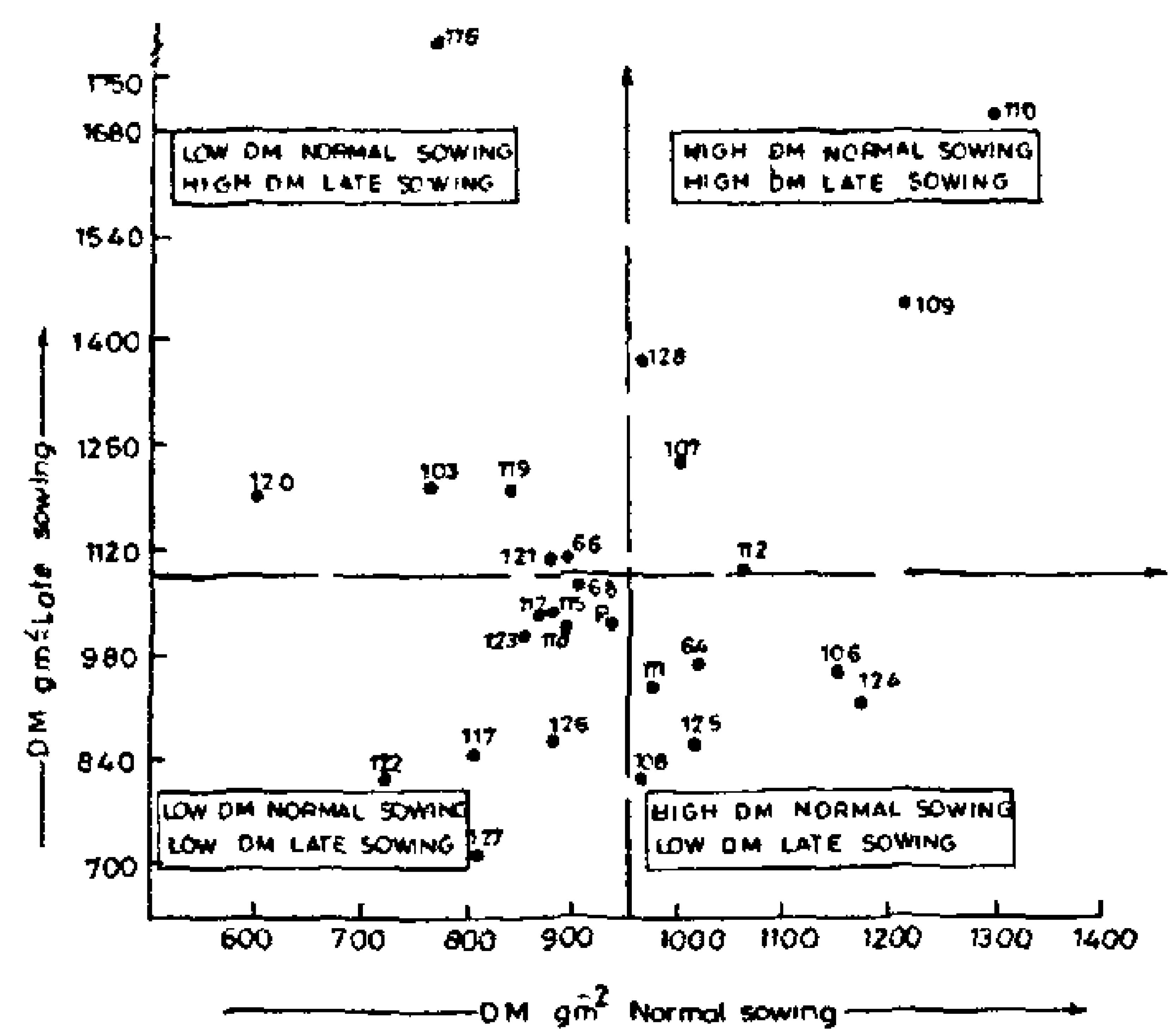

Figure 1. Dry matter production in *Cicer arietinum* cultivar JG-62 and its mutants in normal and late sown conditions.

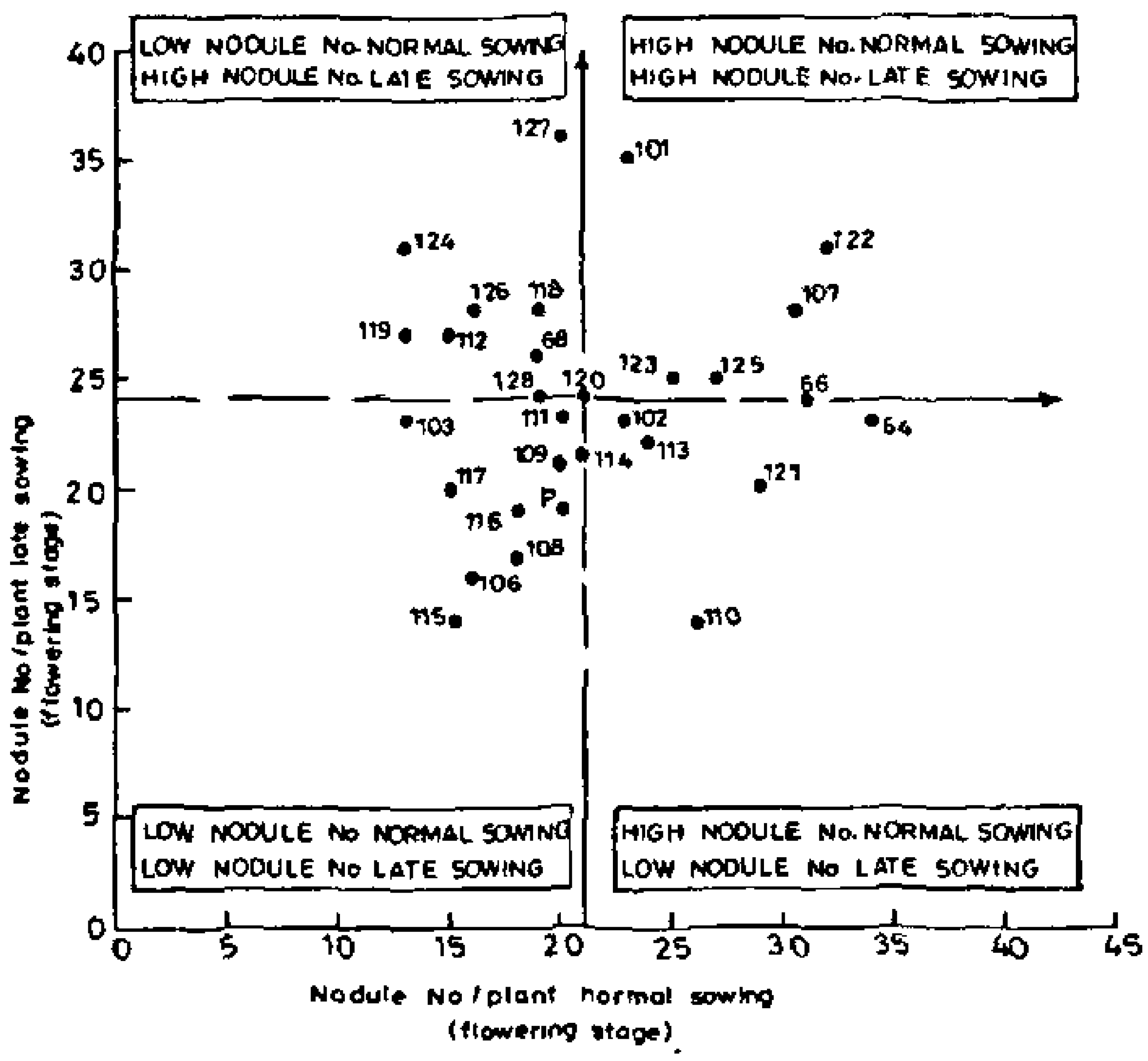

Figure 2. Nodule number in *Cicer arietinum* cultivar JG-62 and its mutants in normal and late sown conditions.

The number of nodules per plant was determined at the time of flowering, since the number of nodules usually declines after flowering[2]. The variants 66, 101, 107, 122, 123 and 125 had more nodules per plant as compared to parent both in normal and late sowings (figure 2). However, the variant 109 which produced more dry matter than the parent, did not show any difference in nodule number while 119 was better only in late sowing.

The seed yield varied from 100–430 g/m^{-2} with an average of 210 g/m^{-2} for the 20 genotypes in early sowing. The yield of parent was 280 g/m^{-2}. In late sowing, the seed yield ranged from 220–540 g/m^{-2}, with an average of 355 g/m^{-2}. The yield of parent was 327 g/m^{-2} (figure 3). The variant 109 gave higher yield than the parent in both the sowings. In late sowing 116 and 119 also gave higher yield than the parent. There were several variants which gave seed yield poorer than the parent. In addition, the variants 109 and 119 had higher seed weight than the parent (figure 4). This is a distinct advantage in many respects. As a result of the above changes, it was observed that the harvest index (HI) also changed. Some mutants were distinctly better

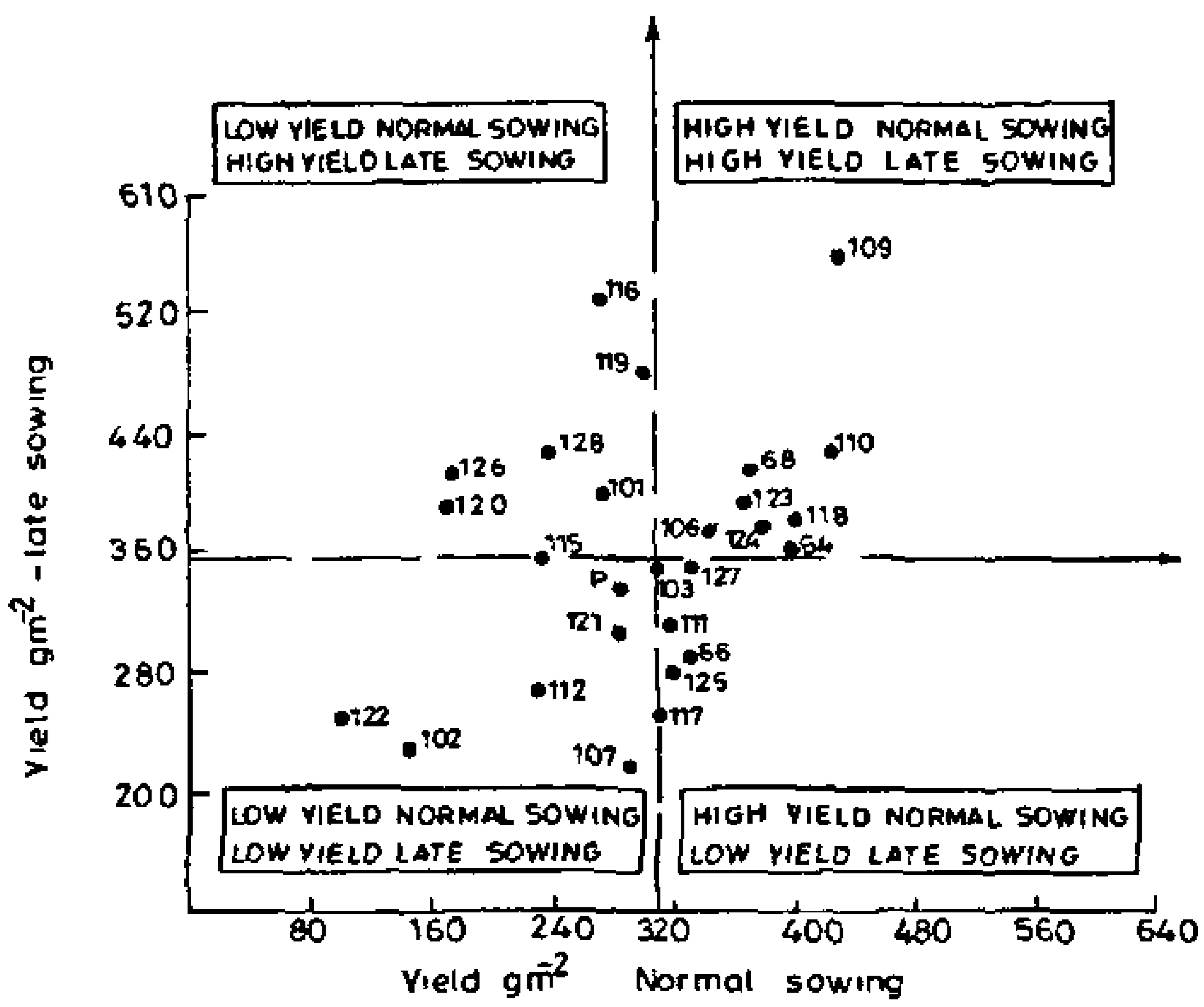

Figure 3. Yield in *Cicer arietinum* cultivar JG-62 and its mutants in normal and late sown conditions.

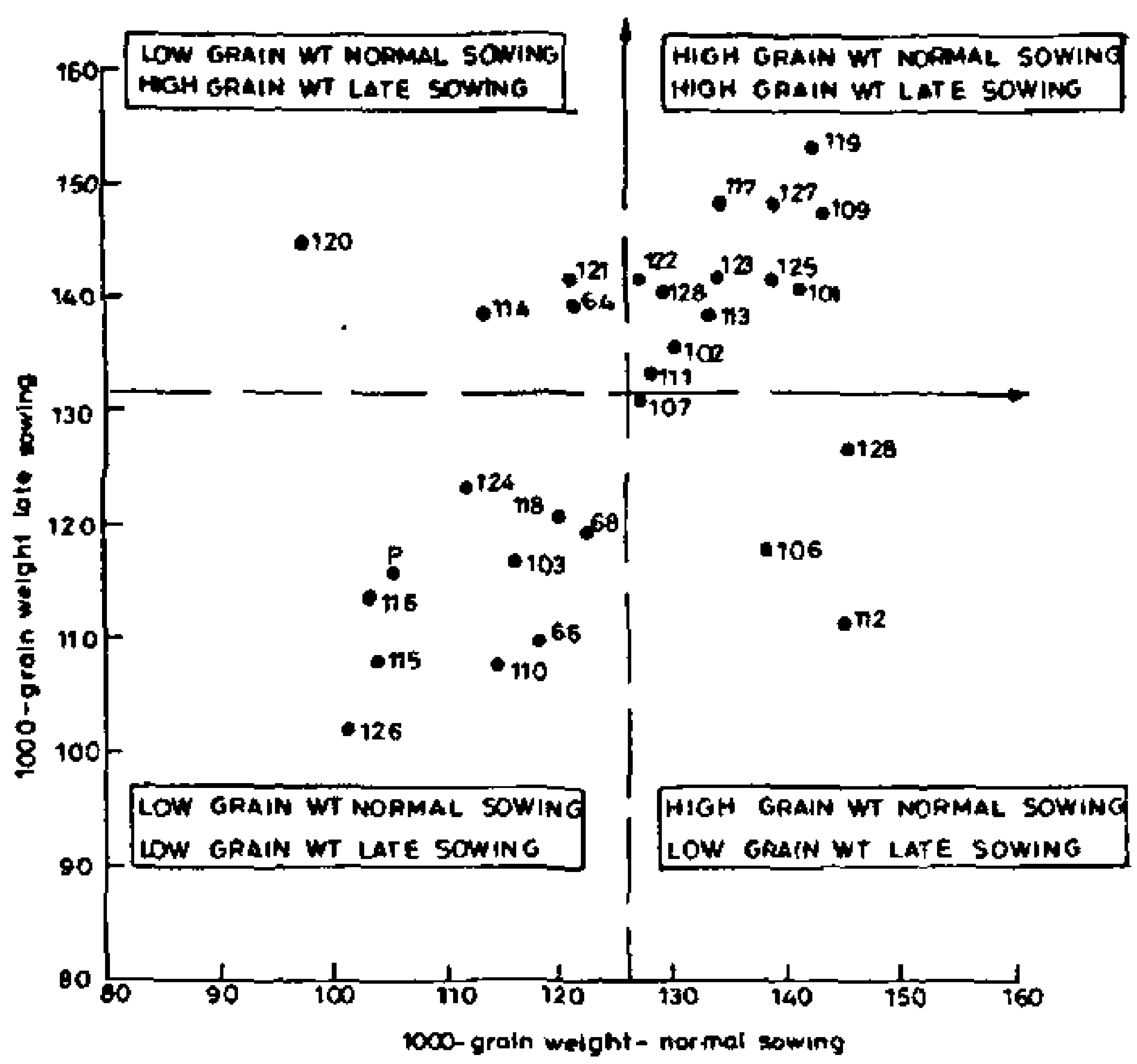

Figure 4. 1000 grain weight in *Cicer arietinum* cultivar JG-62 and its mutants in normal and late sown conditions.

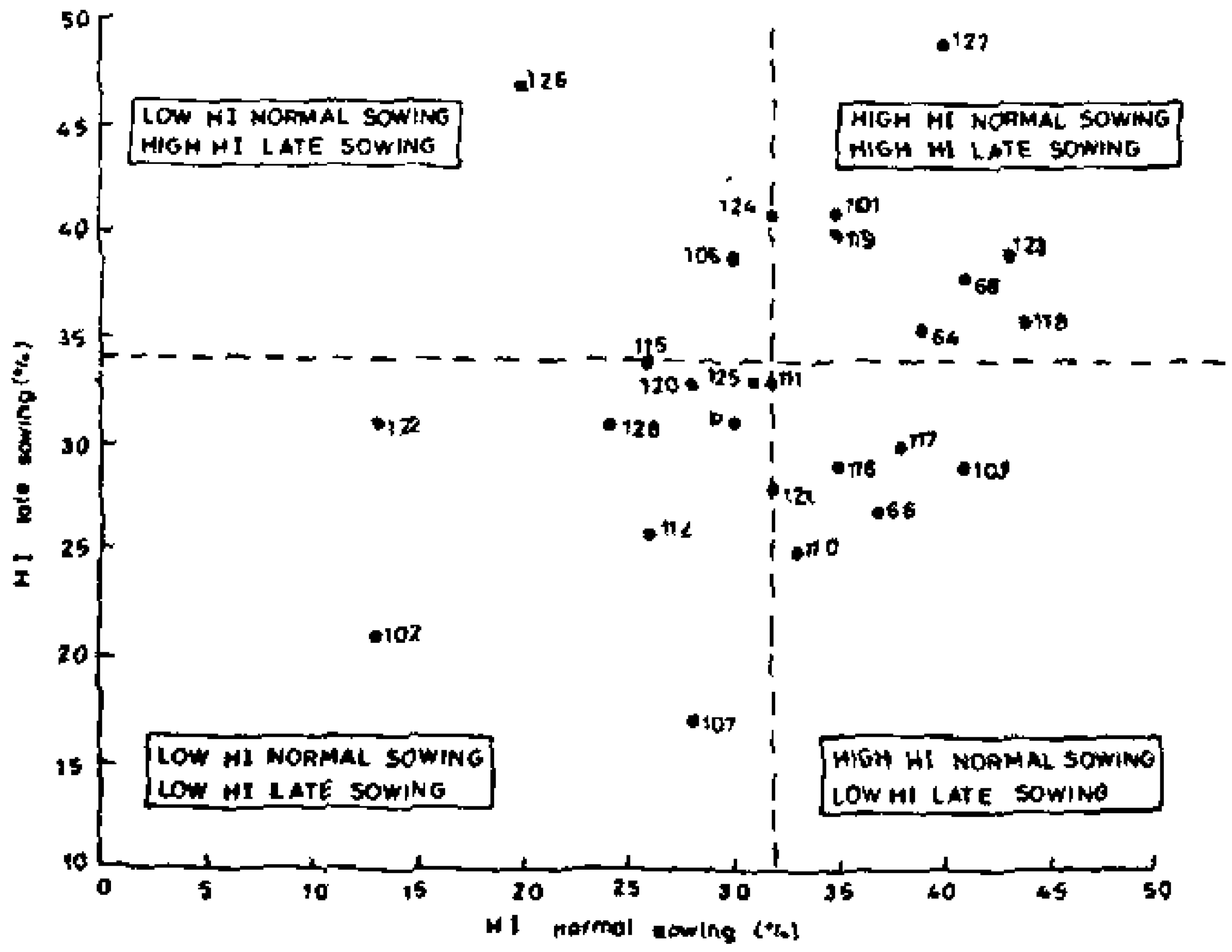

Figure 5. Harvest index in *Cicer arietinum* cultivar JG-62 and its mutants in normal and late sown conditions.

than the parent in this respect (figure 5).

From the above account, it is clear that the following objectives have been achieved: (i) The mutants suitable for sowing in late November have been obtained. Indeed, if irrigation is available even the parent JG-62 could give as much yield in late sowing as in 'normal' sowing. (ii) Mutants have been isolated which produce more dry matter and seed yield than the parent. One of the main reasons for this seems to be the change in pattern of growth of the plant. (iii) The mutants 109 and 119 have now been tested in agronomic trials where they have proved superior to the parent and the best recommended variety. (iv) Seeds of the mutants 109, 110, 116 and 119 have been supplied to the ICRISAT where they have been given the following numbers: ICC Nos. 11889, 11890, 11891, 11892, 11893. (v) It is concluded that if minor mutations in growth pattern are obtained, they may have significant impact on plant structure. Further studies on photosynthetic characteristics, responses to water deficit, grain development, malic acid exudation are now in progress.

The authors thank Dr. M. S. Swaminathan for suggesting this problem and taking keen interest in this programme.

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YIELD INCREASES OF WHEAT AFTER INOCULATION WITH *A. CHROOCOCUM* AND PHOSPHOBACTERIA

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EVIDENCE is growing of the favourable effect of *Azotobacter* and phosphate solubilising bacteria (phosphobacteria) in providing plant nutrients to cereals and vegetables and in supplementing the expensive inorganic fertilizers. The microbial inoculants in combination with inroganic and organic manures have augmented the yields and nutrients uptake by several crops. Seed inoculation with phosphate dissolving microorganisms have been found to increase the yield and phosphorous uptake by several crops[1-4]. Also, inoculation with *Azotobacter* has shown increased crop productivity[5-7]. However, reports are scanty on the use of mixed inoculants of nitrogen fixing and phosphate solubilising bacteria[8,9]. Therefore, the present study was conducted to see the effect of *A. chroococcum* and phosphobacteria (*B. polymyxa, P. striata*) as mixed inoculants on yield and nutrient uptake by wheat under field conditions.

The field soil was alluvial sandy loam in texture having a pH 8·2; organic carbon, 0·57%; total nitrogen, 0·048% and available phosphorus 8·5 ppm. The land was fallow in the kharif season and was amended with 2% farmyard manure before conducting the experiment. The field was well pulverized and divided into 1 m^2 plots. All the recommended agronomical and cultural operations were done except the use of inorganic fertilizers for raising the crop. The inoculants (*A. chroococcum, B. polymyxa* and *P. striata*) were prepared and inoculated on seeds as mentioned elsewhere[8]. The counts were made by dilution plating on nitrogen-free Jensen's and tricalcium phosphate Pikonskayai media for *A. chroococcum* and phosphobacteria respectively (table 1). Each treatment was replicated thrice in randomized block design. The crop was harvested after 98 days and grain and straw yields were recorded on dry weight basis. Nitrogen and phosphorus were determined using Jacksons[10] method.

The experiment was conducted without addition of inorganic fertilizers to test the potentiality of microbial inoculants on improving the crop productivity. However, organic matter was added to increase the efficiency of the cultures as they show only a marginal increase in soils of low organic matter content. Seed bacterization increased appreciably the