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Variation in phosphorus use efficiency among 16 wheat genotypes grown in a phosphorus deficient soil

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Abstract
Phosphorus (P) deficiency is one of the yield-limiting factors in *Vertisols* in various part of the world. The objective of this study was to evaluate the growth and P-use efficiency of 16 wheat genotypes at four phosphorus levels (Control, 40, 80 and 120kg P ha^{-1}). Plant height, total tillers, effective tillers, test weight and phosphorus use efficiency were significantly affected by wheat genotypes and phosphorus levels. On the basis of P-use efficiency, genotypes were classified as efficient and responsive, efficient and nonresponsive (ENR), nonefficient and responsive (NER), and nonefficient and nonresponsive (NENR). Genotypes which produced higher effective tillers in a low level of phosphorus and respond well to added phosphorus are the most desirable because they are able to express their high yield potential in a wide range of phosphorus environment. Genotype HD 2864, HD 2932, Raj 4238, HI 8113, CG Genhu 4, GW 366, GW 273, CG Genhu 4 fall into this group.

Keywords: phosphorus, 16 wheat genotypes, phosphorus deficient soil

Introduction
Low natural phosphorus level and high P fixation capacity often create growth-limiting conditions for crop growth in soils. Growing P-efficient genotypes may be agronomically valuable, especially with the present interest in low-input agriculture.

Phosphorus use efficiency has been defined in several ways (Fageria, 2009) [2]. However, in phosphorus deficient soils, the most useful efficiency is nutrient-use efficiency which can be defined as the biomass production per unit of nutrient absorbed. The nutrient use efficiency is also referred to as nutrient efficiency ratio. Fageria and Baligar *et al* (2008) [3] reported significant differences in wheat genotypes for plant height, effective tillers, shoot and root dry weight, test weight, uptake and use efficiency for phosphorus when grown at deficient and sufficient levels of phosphorus. Further, based on grain yield and phosphorus use efficiency, they were able to classify genotypes into phosphorus efficient and inefficient types (Fageria *et al.*, 2011) [4].

In the present investigation, we used phosphorus use efficiency as the main criterion with the objective to identify and differences among wheat genotypes in response to increasing phosphorus levels on soils.

Materials and Methods
A field experiment was conducted on *Vertisol* of Instractional Farm, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, and Chhattisgarh during *Rabi* season of 2017-2018 and 2018-2019. The experimental soil (*Vertisol*) was fine montmorillonite, hyperthermic, chromustert, locally called as Kanhar and is identified as Arang II series. It is usually deep, heavy clayey, dark brown to black in colour and neutral to alkaline in reaction due to presence of lime concentrations. The initial status of soil pH was 7.7, CEC-38 Cmol kg-1, organic C (6.2 g kg-1), alkaline KMnO4-N (236 kg ha-1), Olsen P (15.35kg ha-1), CaCl2 extractable S (18.66 kg ha-1), high in amm. Acetate extractable K (474 kg ha-1) and higher exchangeable Ca (6325 kg ha-1) and Mg (966kg ha-1).

The experiments was laid out in strip plot design with 16 horizontal plots which represented genotypes *viz.*, HD 2864, HD 2932, RAJ 4238, MP 3336, HI 8113, GW 366, GW 322, Rattan, Sujata, CG Genhu 2, CG Genhu 3, CG 4, MPO 1215, HI 1500, GW 273 and MP 3288. Four vertical plots represented by phosphorus levels *viz.*, Control, 40, 80 and 120 kg P ha^{-1}. The common dose of N and K was applied @100 and 40kg ha^{-1}, respectively. "N was applied in three equal splits at sowing, tillering and ear head initiation stage," whereas P and K was applied as basal. Seeds of wheat genotypes were obtained from the Plant Breeding and Genetics Department, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh.

Results and Discussion

Plant growth, yield attributing characters, P uptake and phosphorus use efficiency were significantly affected by wheat genotypes and different levels of phosphorus. Plant height, total tillers, effective tillers and test weight were significantly increased with increasing phosphorus levels in the soil. The significant interaction between phosphorus x genotypes for number of effective tillers indicates that genotypes HD 2864, HD2932, RAJ 4238, GW 366, HI 8113, CG Genhu 4 and GW 322 were more responsive to the P fertilization while HI 1500, MP 3288, Sujata and Rattan were the less. The increase in number of effective tillers of genotypes was associated with an increase in panicle number, with increasing phosphorus rate. Fageria (2007) [5] reported that among yield components, panicle number is the most effective component in yield increasing rice yield.

Increased plant height was reported at higher levels of phosphorus application, resulting in the availability of higher energy in the form of ATP molecules, which would have contributed to cell elongation, resulting in taller plants. The increase in plant height in response to higher levels of P was in conformity with the findings of Ashiono *et al.*, (2005) [1] and Pratyusha (2014) [6]. The variation in plant height variability into heritable and non-heritable to obtain a true indication of the genetic variability, present in the genotypes. Similar trends and observations have been reported by a lot of wheat workers across the globe.

On the basis of phosphorus use efficiency genotypes were classified into four groups as shown in Fig.1. The first group was efficient and responsive (ER) genotypes, and produced above the average yield of all the genotypes and responsed well to applied P. The genotypes falling into this group were HD 2864, HD 2932, Raj 4238, HI 8113, CG Genhu 4, GW 366, GW 273, CG Genhu 4. The second group included efficient and non-responsive (ENR) genotypes, and these genotypes produced more than average yield, but response to P application was lower than the average of all genotypes and no one genotypes falling into this group. The third group of genotypes are known as nonefficient and responsive (NER). These genotypes, which produced less than average dry matter yield but responded to P application above the average of 16 genotypes, included GW 322 and CG Genhu 2 genotypes. The last group of genotypes, classified as nonefficient and nonresponsive (NENR), produced less than average yield, and response to applied P was also less than average and genotype MP 3336, Rattan, Sujata, HI 1500, MPO 1215, MP 3288 fall into this group.

The genotypes, which fall into the group ER, are the most desirable as they yield well at low P and also responded well to apply P and can be utilized under low as well as high technology with reasonably good yield. The second most desirable group of genotypes is ENR. These can be planted under low P levels with more than average yield. The NER sometimes can be used in breeding programs for their P-responsive characteristics. The most undesirable genotypes are the NENR type.

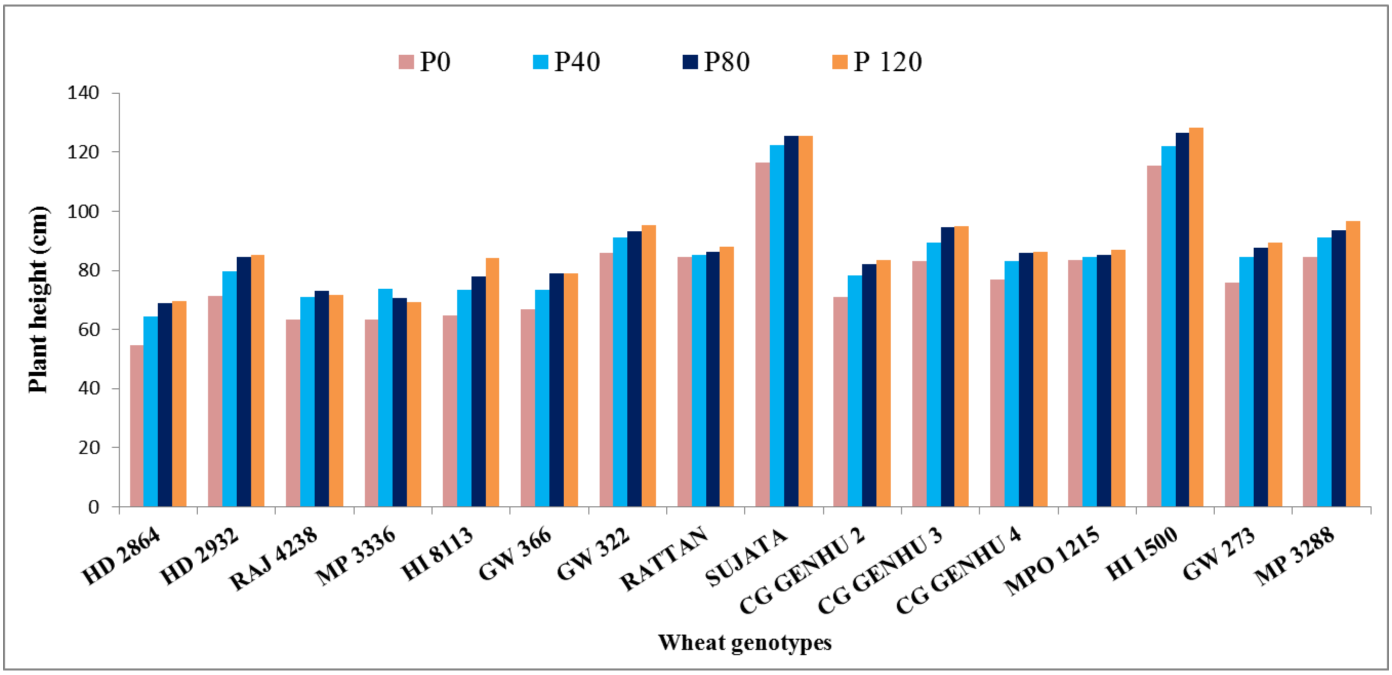

Fig 1: Plant height as influenced by wheat genotypes and phosphorus levels

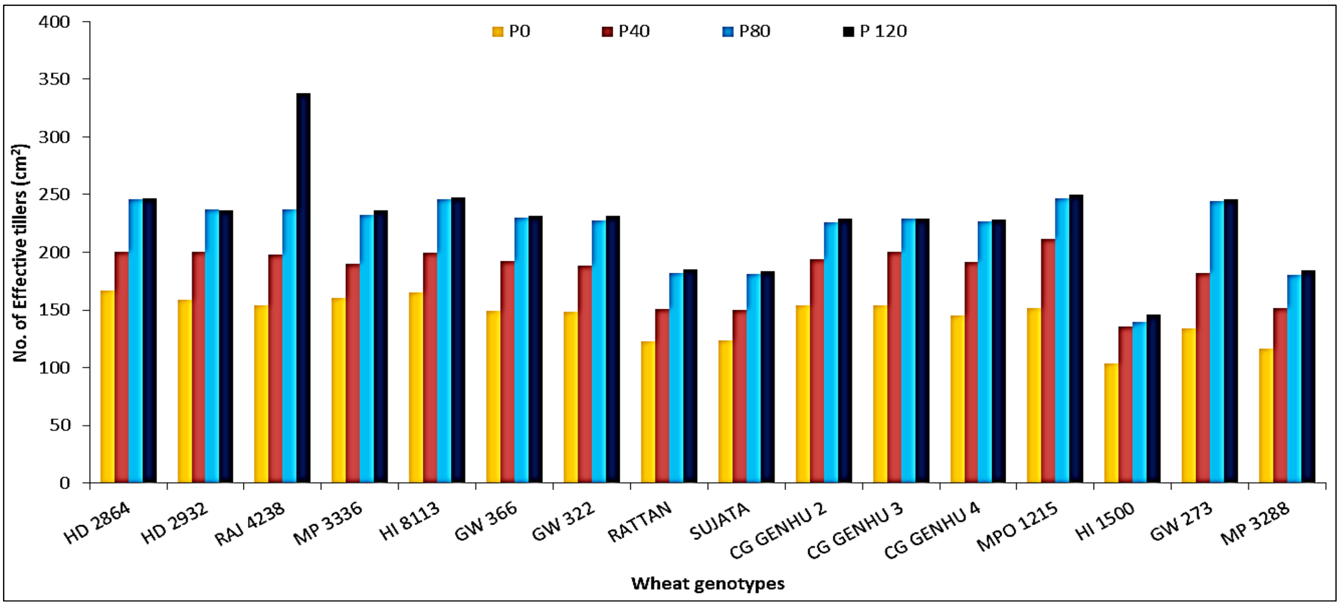

Fig 2: No. of effective tillers as influenced by wheat genotypes and phosphorus levels

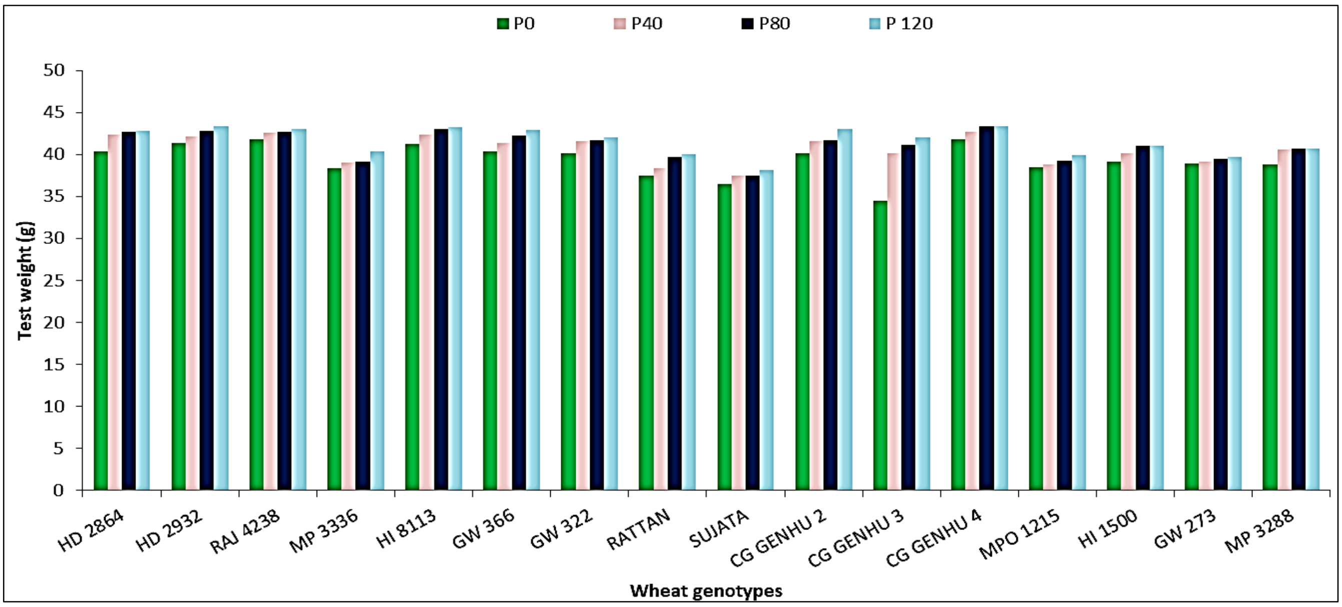

Fig 3: Test weight as influenced by wheat genotypes and phosphorus levels

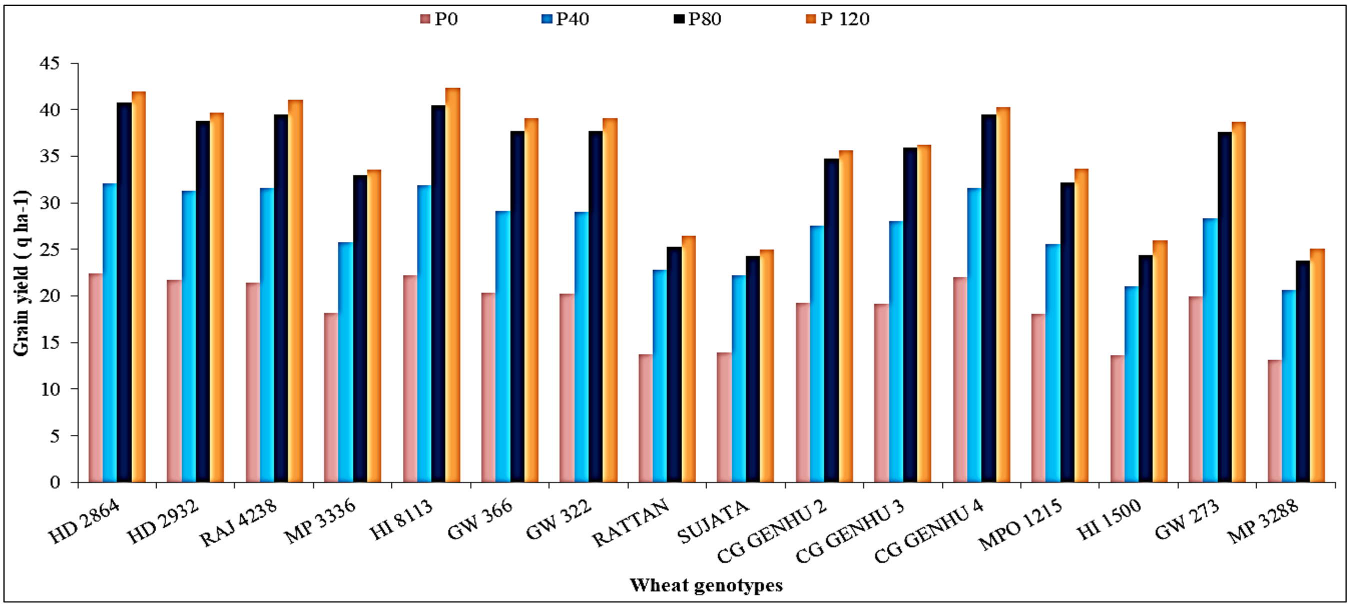

Fig 4: Effect of wheat genotypes and phosphorus levels on grain yield

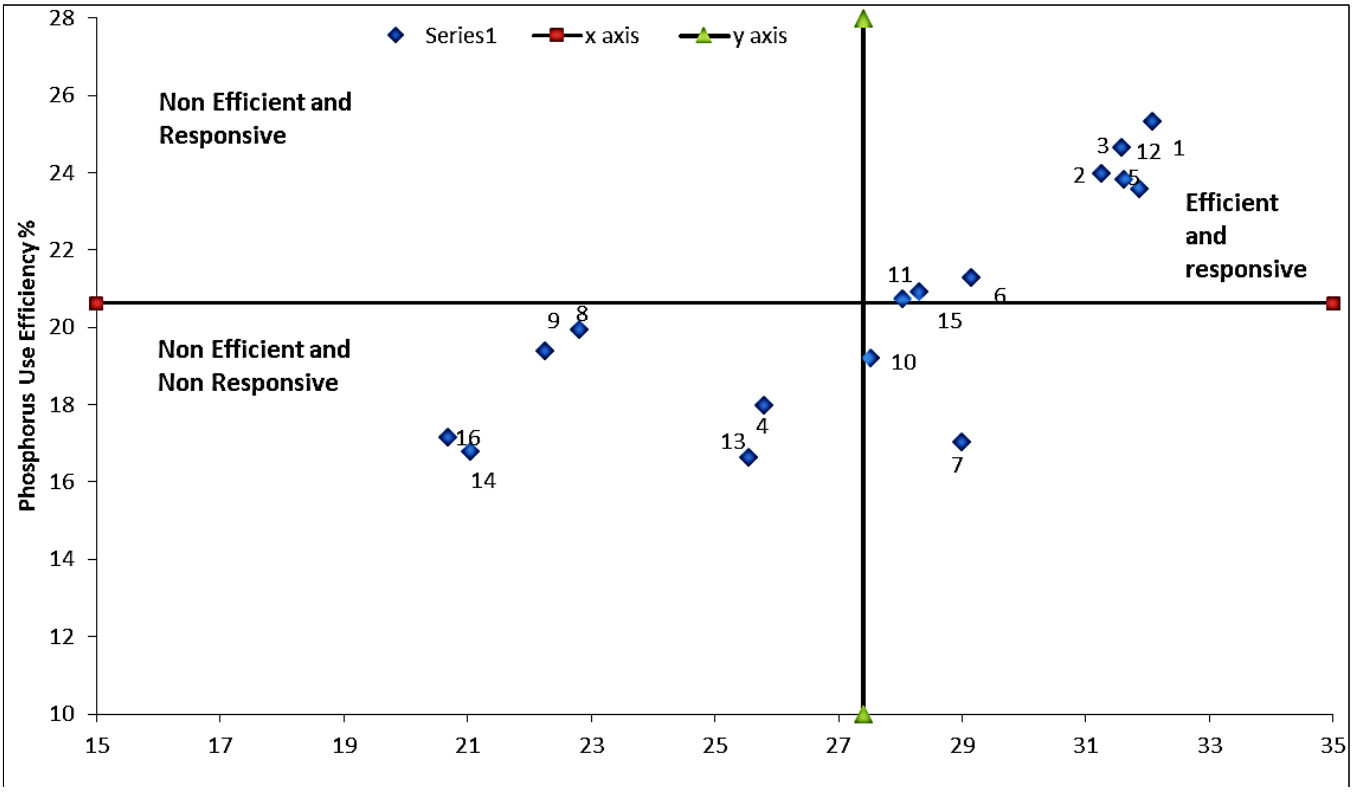

Fig 5: Average grain yield (q ha^{-1})

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