RESEARCH ARTICLE

Assessment of Growth and Biomass Production among different Varieties of Chickpeas in Bundelkhand Region of Uttar Pradesh

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Abstract

Chickpeas are the most popular pulse crop of India, popularly known as gram or Bengal gram, mainly grown in *Rabi* season. Chickpeas are a rich source of highly digestible dietary protein. Though the crop has huge importance, no detailed studies are available on morphological and growth parameters with reference to this crop sown in the Bundelkhand region of India. Here, we compared the plant growth and yield among different varieties of chickpea under farmer's field conditions and screened the high yielding varieties for the Bundelkhand region of Uttar Pradesh. Different varieties of chickpeas *viz.*, Avrodhi, Subhra, Ujjwal, Red gold, Pant-G-186, JG-11, Radhey, DCP-92-3, and HK94134 were analyzed in terms of growth and morphological parameters to screen the best adaptive variety with the highest yield under rain-fed conditions of that particular region. Field evaluation based on phenological traits and biomass patterns was carried out in randomized plots with three replicates for each variety. We observed significant differences in the majority of evaluated traits among the different varieties. Although, the plant height was better in the variety "Ujjwal" altogether, "Radhey" variety was observed to have the highest pod number. The above-ground biomass was again highest in *Radhey* with an average of 31.77 ± 3.38 g plant^{-1} followed by *Avarodhi* (30.33 ± 2.64 g plant^{-1}) and *Subhra* 19.83 ± 3.08. From the present findings, it may be concluded that variety *Radhey* has the highest carbon sequestration potential with the highest yield in the rain-fed conditions, followed by Avarodhi and JG-11.

Keywords: Bundelkhand, Carbon sequestration, Chickpeas, Drought sensitive varieties, Rainfed condition.

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Introduction

Chickpea (*Cicer arietinum* L.) is a legume crop of the family Fabaceae. Originated in southeastern Turkey (Ladizinsky, 1988), it is known as gram or Bengal gram and is sometimes known as Egyptian pea, or chana. The chickpea is the third most important crop in the world after dry bean and pea. Globally, it is grown over an area of 13.98 million hectares (mh) with a production of 13.73 million tons and productivity of 982 kg ha^{-1} (FAOSTAT, 2016). The major chickpea producing countries are India, Australia, Pakistan, Turkey, Myanmar, and Ethiopia, which account for about 90% of world chickpea production.

India is the largest producer of chickpea in the world, sharing around 71.96% of the total area with a productivity of 995 kg ha^{-1} (FAOSTAT, 2016). In India, chickpea cultivation was 5.91 mh, with the production of 4.24 mt during 2002-03. During 2013-14, Chickpea production exceeded 9.5 mt attaining the highest peak in production in the history of India. The production was estimated to witness a setback during 2014-15 due to hostile weather conditions predicted with a total production of 7.17 mt (Dixit, 2015). Grain legume production is severely restricted by drought (Grzesiak *et al*., 1996; Sinclair *et al*., 2007; Sincik *et al*., 2008), which poses a significant threat to food security (Boyer, 1982). Given the complex genetic architecture and unpredictable occurrence, breeding against abiotic stresses has always been a challenging task. Further, drastic climate changes have caused phenotypic plasticity implying changes in the phenotype of the plant (Nicotera *et al*., 2010), and this phenotypic plasticity permits to adjust their form and function according to the change of resource and habitat (Magyar *et al*., 2007). Tolerance to abiotic stresses exhibits complex quantitative inheritance that is also influenced by a number of genetic and environmental interactions.

Though chickpea is considered as a drought-tolerant crop, it faces various abiotic stresses during its life cycles such as drought, cold, terminal heat, and salinity (Ryan, 1997; Millan *et al*., 2006), and on the other hand, it also encounters waterlogging, acidity, and metal toxicity stresses. The yield losses due to abiotic stresses (6.4 million tons) may exceed those caused by biotic stresses (4.8 million tons) (Ryan, 1997).

The problem aggravates further if sowing time is delayed beyond the optimum sowing time. Yield loss in chickpea can vary between 30 and 60% depending on variety, location, and

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climatic conditions during the sowing season. Similar losses have been reported from other warm winter sites in India (Palled *et al*., 1985). Morphological, phenological characters associated with drought tolerance in chickpea are early maturity, early growth vigor, fast ground coverage, large seed size, and root growth habit. These are earliness to escape from drought and desiccation avoidance through reduced transpiration loss and increased water uptake (Murshed, 2000). Proper understanding of this relationship could be vital for future yield improvement of chickpea in late sown areas of the country. Keeping these points in mind, the experiment has been aimed to study the inter varietal differences in growth and morphological attributes and the biomass pattern among different varieties of chickpea in the rain-fed condition of Bundelkhand region of Uttar Pradesh.

Materials and Methods

Different varieties of chickpeas *viz*., Avrodhi, Subhra, Ujjwal, Red gold, Pant-G-186, JG-11, Radhey, DCP-92-3, and HK94134 were analyzed in terms of growth, physiological attributes and yield in order to screen the best adaptive variety with the highest yield under rainfed conditions. The field experiment was set up in Banda district of Bundelkhand region in Uttar Pradesh. Banda is geographically located at 25.4796°N latitude and 80.3380°E longitude covering a total area of 4413 km^2. The region is known to be a drought-prone area, and for several years the region has faced deficit rains leading to water scarcity, particularly for agriculture-related activities. The average annual rainfall is 902 mm. The climate is typical subtropical penetrated by long and intense summers. About 80% of the annual rainfall is received from the south-west monsoon. May is the hottest month with mercury shooting up to 47°C. With the advance of monsoon by mid of June, the temperature starts decreasing. January is usually the coldest month, with temperature going down to 5.8°C. The relative humidity is highest in August, about 85% and lowest in April. The soil in which the experiment has been conducted has the following nutrients status. pH 6.8, EC, mhoscm^{-1} 0.92, nitrogen (N_2) 14.3 mg kg^{-1}, 27.3 phosphorus (P) mg kg^{-1}, 0.59, potassium (K) mg kg^{-1} 35.4, manganese (Mn) mg kg^{-1} 4.6, iron (Fe) mg kg^{-1} 48.8, cobalt (Co) mg kg^{-1} 0.5, copper (Cu) 12.2mg kg^{-1}.

All the varieties were sown in mid of October in a randomized complete block design with three replications at the village "Ujrehta" of Banda district. Each plot consisted of four rows; the inter-plant spacing was 15 cm, and row to row spacing was 30 cm, respectively. Chickpea seed was sterilized in 0.5% (v/v) sodium hypochlorite solution for 5 minutes and then thoroughly washed. Seed treatment with *Trichoderma viride* @ 5 gm kg^{-1} seed for seed and soil-borne diseases, farm manure at the rate of 10 ton ha^{-1}, fertilizers N:P:K (20:40:25) kg ha^{-1}. Seed treatment with *Rhizobium* and *PSB* culture with 20 gm kg^{-1} seed was applied.

Morphological and growth parameters were measured for mature plants in all different varieties. Growth parameters include plant height, the diameter of plants, and morphological parameters include the number of branches, pod number, and flower number. Stem diameter was measured by vernier caliper at 2 cm above the ground.

Finally, the plants were harvested at full maturity stage. Total shoot length and root length were measured after harvesting. Fresh above-ground and below-ground biomass were measured, and total biomasses were determined at the maturity stage. The measurements were carried out by selecting 30 random individual plants from each variety, and average values were calculated. Fresh biomass was separated into leaf, stem, root, and pod biomass for calculating each component biomass. Fresh samples of each component were oven-dried at 70°C to constant weight, and then dry biomass was calculated.

Results and Discussion

Plant height was varied significantly among different varieties taken under the study. The variety *Ujjwal* was observed to attain the maximum height (49.58 cm) followed by variety *Radhey* (37.5 cm), *Avrodhi* (36 cm), and *Shubra* (34.1 cm). However, it was interesting to note that the latter three varieties had no major significant differences in height. HK94 showed the least growth in terms of height in comparison to all other varieties (Fig. 1).

Flower development started from the month of January and continued up to mid of February month for *Avarodhi*, *Radhey*, JG11, and Pant-G-186 varieties. Late flower arises from *Ujjwal* and Subhra varieties. Pod set commenced 20 days after flowering for *Radhey,* followed by *Avarodhi*. DCP-92-3 and HK94134 showed a late pod setting in comparison to other varieties. At maturity, the morphological patterns of all the varieties were studied, which included the number of branches, number of flowers and number of pods in each plant. Primary as well as secondary branches, were included in the study. Primary branches were defined as stems growing from the main base, including mainstream and branches growing up to three nodes of the mainstream. Secondary branches were also counted, which were arising from the primary ones. However, tertiary branches were not included in the study. The number of branches was found to be maximum in *Radhey* (19.4), which was followed by *Avarodhi* (17.33). The least number of branches were found in HK 94(10.6), DCP-92(11.2), and *Shubra* (12). The numbers of flowers were found maximum in *Avrodhi* with an average of 25.2 ± 1.4, followed by JG11 and *Radhey* with an average value of 22.8 ± 3.26 and 21.5 ± 2.6, respectively. The least number of flowers was noticed in *Ujjwal*. Pod numbers are very crucial in terms of yield as it determines the actual yield of the plant. The maximum pod numbers were observed in *Radhey* with an average value of

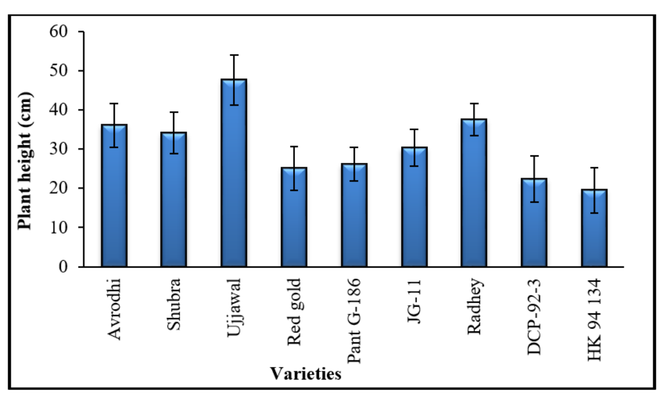

Fig. 1: Plant height of different chickpea varieties grown in rainfed condition

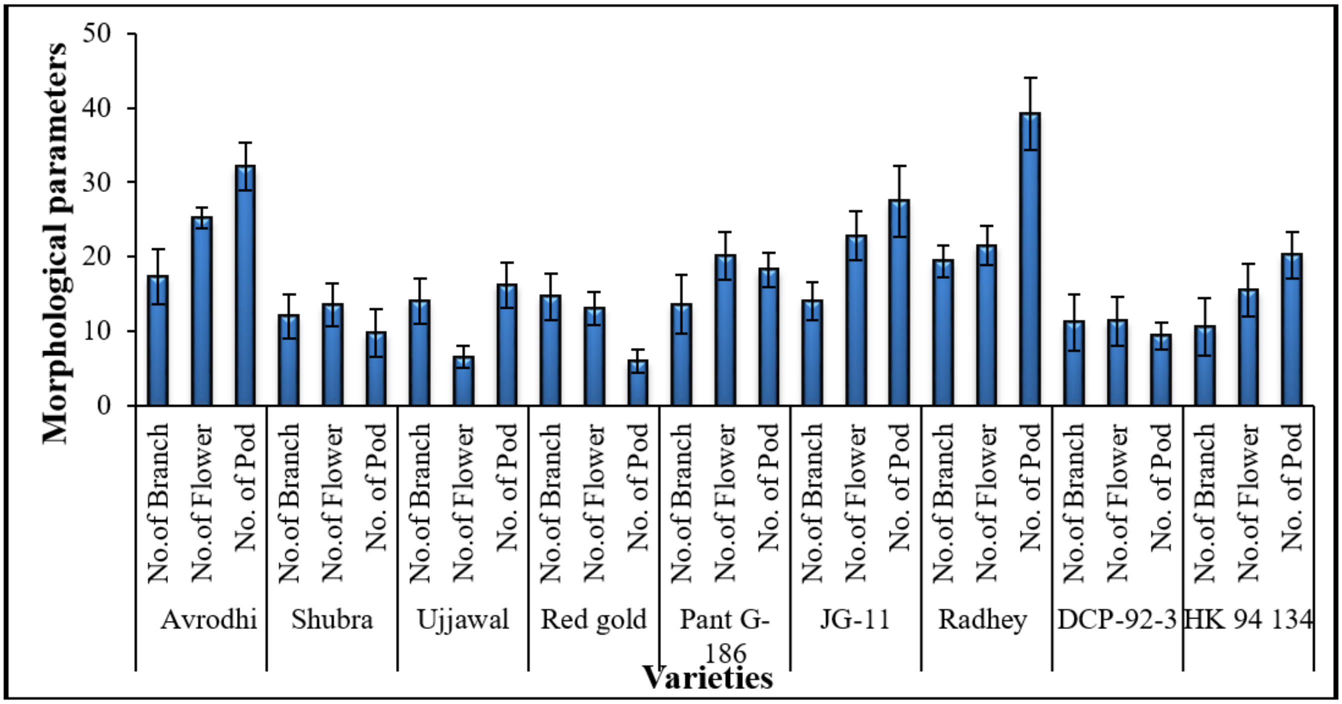

Fig. 2: Morphological parameters of different chickpea varieties

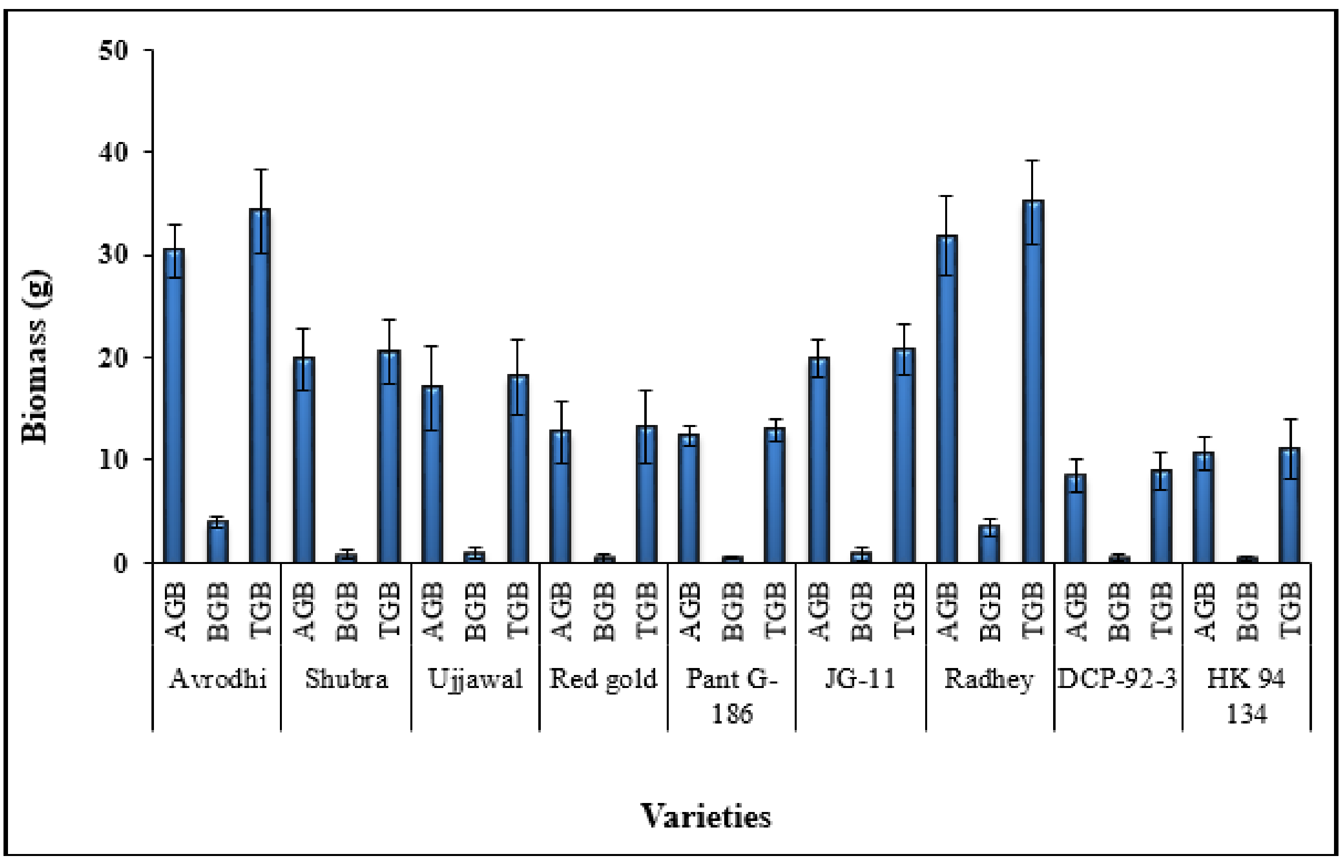

Fig. 3: Biomass pattern of different chickpea varieties grown in Bundelkhand region

39.2 ± 4.7, followed by *Avarodhi* and JG-11 with average values of 32.11 ± 3.18 and 27.5 ± 4.72, respectively (Fig. 2).

Above ground, below-ground biomass, pod weight, and total biomass were measured in all the varieties at the full maturity stage (Fig. 3). Above-ground biomass was highest in the variety *Radhey* with an average value of 31.77 ± 3.88 g plant^{-1} followed *Avarodhi* with an average value of 30.3 ± 2.64 g, respectively. The above-ground biomass was least in DCP-92-3 amongst all the selected varieties. The highest below-ground biomass was observed in *Avarodhi* with an average value of 3.90 ± 0.56 g, followed by *Radhey* with an average value of 3.40 ± 0.85 g. The least below-ground biomass was observed in HK-94 with an average value of 0.40 ± 0.17 g. The total ground biomass was highest in *Radhey* with an average value of 35.17 ± 4.05, followed by *Avarodhi* with an average value of 34.23 ± 4.02 g. The lowest total ground biomass was observed in DCP-92-3 with an average value of 8.90 ± 1.90 g, followed by HK-94 with an average value of 11.07 ± 2.85 g. The highest yield of *Radhey* and *Avarodhi* variety could be due to high root and shoot weight. The root length was also higher in *Radhey* and *Avarodhi* varieties. A deep root system is seen to have in plants to avoid water stress. Plants grown in the drought-prone region develop various mechanisms to enhance their drought tolerance, including the well-developed root system, osmotic adjustments, and certain leaf morphologies (Levitt, 1980; Kramer, 1983; Jones, 1992; Larcher, 1995). Thus, a better root system helped these plants to absorb water from a greater volume of soil, which in turn helps to avoid water stress and hence sustain growth under water limiting conditions. Better root systems found in *Radhey* and *Avarodhi* variety may be one of the reasons for its adaptation in marginal moisture conditions. In totality, we could infer that *Radhey* was the superior variety in terms of biomass production among all. Hence, *Radhey* variety may be recommended to farmers as high yielding chickpea variety for cultivation in the Bundelkhand region of Uttar Pradesh.

Conclusion

In the present study, different chickpea varieties were screened, in which *Radhey* followed by *Avarodhi* varieties were found to be best suited for the region in terms of growth parameters and yields. A substantial variation was noticed in all recorded parameters due to varietal differences and environmental stress. Drought sensitive varieties had shown a significant reduction in growth and morphological parameters. However, the lower production rate than that of other regions of the country may be due to a lack of farmer awareness and knowledge regarding the recent technologies and best quality seeds that are specific for the Bundelkhand region. The present study will be helpful for Bundelkhand farmers in terms of choosing the best adaptive variety of chickpea for better overall production and higher yield.

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