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Evaluation of chickpea (*Cicer arietinum* L.) cultivars under organic production system

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Abstract
The new research work entitled "Evaluation of chickpea (*Cicer arietinum* L.) Cultivars under organic production system" was performed at Research cum Instructional Farm IGKV, Raipur (C.G) during *Rabi* season of 2020-21. The Randomized Block Design was used to evaluate the experiment with three replications. The experiment consisted of 10 chickpea cultivars. After the rice harvest, the crop was organically cultivated under irrigated condition. The treatment consisted of different chickpea cultivars under organic production system. Chickpea cultivars *viz.* V_1 - JAKI-9218, V_2 - RG 2009-01, V_3 - Vaibhav, V_4 - RG 2009-16, V_5- JG-130, V_6 - Vishal, V_7 - JG-226, V_8 - Daftari-21, V_9 - JG-14 and V_{10} - Indira chana-1. The result revealed that cultivar Vaibhav achieved the highest values for growth, yield attributes, and seed yield (1494 kg ha^{-1}). However, the seed yield of different chickpea cultivars was statistically at par with RG2009-01 and RG2009-16. The different cultivars of chickpea did not have a significant impact on soil chemical properties such as pH, EC, organic carbon, and available NPK. With respect to quality parameters, highest protein content (%) in seed for chickpea was recorded in the cultivar Indira chana^{-1} which was comparable to JG-14, Vaibhav, JAKI-9218, JG-13 cultivars. The lowest value of protein content (19.42%) was registered in JG-226. Among the all chickpea cultivars the highest net realization (Rs. 59481 ha^{-1}) and benefit cost ratio (2.88) was obtained with cultivar Vaibhav, followed by RG 2009-01 and RG 2009-16, *i.e.* (Rs. 56674 and 54592 ha^{-1}) respectively.

Keywords: Cultivars, chickpea, yield, organic

Introduction

Pulse crops play a crucial role in Indian agriculture. Apart from their rich protein content, they contribute to the sustainability of cropping systems. Their ability to harness atmospheric nitrogen through biological nitrogen fixation (BNF) makes them economically viable and environmentally friendly. Pulses constitute a vital component of the predominantly vegetarian Indian diet. While cereals serve as the staple food and primary energy source, the inclusion of pulses, as the primary source of vegetable proteins, ensures a nutritionally balanced diet. On average, pulses contain 20-25% protein on a dry seed basis, which is nearly 2.5-3.0 times the protein content typically found in cereals.

Chickpea (*Cicer arietinum* L.) stands out as the most significant winter season pulse crop. It serves as a crucial source of protein and plays a pivotal role in the nutrition of a large population in the developing world. Chickpea, known for its high-quality stored protein content, holds a paramount position among pulse crops worldwide. It contributes significantly to low-input farming practices by reducing the dependence on inorganic nutrients. On average, chickpea seeds contain 23% protein, 64% total carbohydrates, 5% fat, 6% crude fiber, 3% ash, and boast a high mineral content. Chickpea ranks as the second most important pulse crop for human consumption and various other uses, following red gram. In 2017, a total of 14.8 million tons of chickpeas were harvested from 14.6 million hectares worldwide (FAO, 2019) [6]. Chickpea holds a prominent position as a primary winter season pulse crop in India. It is cultivated both as a dry pulse crop and as a green vegetable, with the latter being the more common choice among farmers. In 2017-18, chickpea ranked first in terms of cultivated area in India, encompassing an expansive 105.61 lakh hectares. This widespread cultivation resulted in a substantial production of 112.29 lakh tons, with an average productivity of 1063 Kg ha^{-1}. Chhattisgarh state benefits from favorable agro-ecological conditions that are well-suited for chickpea production. In 2019-20, chickpeas were cultivated over an extensive area of 4.34 lakh hectares in the state, resulting in a substantial annual production of 4.56 lakh tons.

The state achieved an average productivity rate of 1050kg ha^{-1} during this period. (Anonymous, 2021) [2].

Chickpea plays a significant role in enhancing soil fertility owing to its nitrogen-fixing ability. During its growth period, chickpea can fix up to 140 kg of nitrogen per hectare (Poonia and Pithia, 2013) [20]. This nitrogen fixation leaves a substantial amount of residual nitrogen in the soil for subsequent crops and contributes an abundance of organic matter, which helps maintain and improve soil health and fertility. Chickpea is a crucial contributor to agricultural sustainability due to its nitrogen-fixing capacity, making it an excellent rotational crop. It enhances soil health by boosting microbial populations and activity in the root zone of the soil. While chickpea can fix nitrogen from the atmosphere, there is compelling evidence that nitrogen fertilizer can increase seed yield, as well as the protein and amino acid content of the seeds. However, chickpea's nitrogen fertilizer requirements are generally lower than those of other crops, yet it still manages to achieve higher yields and improved seed quality (Dhima *et al*., 2015) [3].

The excessive use of inorganic fertilizers in crop production has led to the deterioration of soil health. This overuse disrupts the normal physical and chemical properties of the soil, ultimately affecting the quality of food produced. The detrimental effects of these chemicals result in poor soil structure, reduced microbial activity, and negatively impact the quality of water, food, and fodder. Furthermore, the quality of agricultural produce is compromised as these harmful chemicals can enter the plants and subsequently make their way into the food chain. These concerns have reignited the interest of farmers and researchers in non-chemical sources of plant nutrients such as bio-fertilizers, farmyard manure, green manure, and composts. This renewed interest is driven by factors like the energy crisis, the need for sustainable crop productivity, rising fertilizer costs, and a growing emphasis on ecological sustainability in agriculture. These alternative nutrient sources offer promising solutions to address these challenges and promote healthier and more environmentally friendly farming practices. Hence, to overcome the disturbing situation it is necessary to adopt the practices that can maintain the soil health by moving to organic farming and sustainable system in order to supply qualitative and nutritious food to human beings. The notice of people has increased towards organic farming due to their awareness about crop quality and soil health. (Sharma *et al*., 2008) [12].

Organic farming achieves soil sustainability for organic crop cultivation through the augmentation of soil organic carbon, increased nutrient availability, and the enhancement of microbial populations and enzymatic activity. To ensure both maximum crop yield and sustained soil fertility, it is imperative to employ balanced nutrient sources derived from organic materials such as farmyard manure, vermi-compost, green manure, neem cake, and bio-fertilizers. (Dahiphale *et al*., 2003) [4]. Stagnation and declining productivity of various agro ecosystems are matter of serious worry which is mainly due to the emergence of general multi nutrient deficiencies, imbalanced fertilization and reduction of native nutrient reserves. Sustainability problem caused by the haphazard use of chemical fertilizers and pesticides can be solved with organic farming production system. Organic farming has been intended at conservation and optimized utilization of all natural resources for a reasonable profitability keeping a certain threshold of profit from the farming. All the farming practices have to be redesigned to undo adverse effects that have crept in the current agricultural scenario, while attending to increase the chickpea production.

The pursuit of agronomic enhancement remains constant in the quest to optimize organic farming systems, requiring suitable crop varieties to unlock their full potential. Despite the inherent advantages of organic farming, such as improved soil health and higher-quality produce, maintaining consistently high yields poses a significant challenge within these systems, Modern cultivars have been meticulously bred for conventional farming practices and may struggle to thrive in organic environments, where they confront stressors without the crutch of external inputs. This difference in conditions necessitates the careful selection of varieties adapted to the unique challenges posed by organic farming, which lacks the chemical supplementation of nutrients and pest/disease protection found in conventional agriculture.

Materials and Methods

The experiment "Evaluation of chickpea (*Cicer arietinum* L.) cultivars under organic production system" was performed at Research cum Instructional Farm of IGKV, during *rabi* season of 2020-21. The climate in the region ranges from sub-humid to semi-arid. The soil in the experimental field was classified as *Vertisol*, characterized by varying levels of nitrogen (N), phosphorus (P), and potassium (K) content, specifically low, medium, and high, respectively. These soils also exhibited a neutral ph. The experiment was conducted using a Randomized Block Design, which included three replications and ten different treatments, each corresponding to a distinct cultivar *viz.* V_1- JAKI-9218, V_2- RG 2009-01, V_3- Vaibhav, V_4- RG 2009-16, V_5- JG-130, V_6- Vishal, V_7- JG-226, V_8 - Daftari-21, V_9- JG-14 and V_{10}- Indira chana-1, was sown on December 07, 2020 and harvested on as per their maturity. Throughout the crop's growth period, we diligently measured several yield-related characteristics, such as the number of pods per plant, seeds per pod, seed index, seed yield, and stover yield, following a predetermined schedule to fulfill the research requirements.

Results and discussion

Number of pods $plant^{-1}$

Significant variations were observed in the number of pods per plant in chickpea across different cultivars within the organic production system.

Number of pod $plant^{-1}$ had observed significantly higher in Vaibhav variety of chickpea (56.20), which was at par with RG2009-01(54.20) and RG2009-16 (53.00), while Jaki-9218 was recorded lowest number of pods $plant^{-1}$ (37.33). The variations in yield-related traits among these varieties can be attributed to their genetic makeup. According to Ali *et al.* (2010), in their study of six brown chickpea (*Cicer arietinum* L.) genotypes, including 90261, 93127, 97086, 98004, and 98154, genotype 98004 exhibited a relatively higher number of pods per plant, with a count of 77.58. According to Neenu *et al.* (2014), their study revealed that the variety V2 (JG 11) exhibited a significantly higher number of pods per plant, with a count of 41.75, followed by V3 (JG 315). In the research conducted by Jakhar *et al*. (2016) [11], they discovered that the number of pods per plant varied within a range of 35.07 to 118.00. Genotype IC-83397 produced lowest, while IC-83429 had highest number of pods per plant followed by IC-83321 (83.67), Vishal (83.40) and IC-83348 (81.67).

Number of seeds pod^{-1}

There is no significant effect on the number of seeds per pod among all the chickpea cultivars. However highest numerical value was recorded in Indira Chana^{-1} variety (1.27). Conversely, the lowest number of seeds pod^{-1} (1.19) was observed in the Jaki-9218 cultivar.

Seed Index (g)

There were no significant differences observed among the cultivars in terms of seed index (100 seed weight). However maximum seed index numerical value was observed in Vishal (25.00) variety due to its boldness of seeds whereas, lowest was recorded in JG-14.

Seed yield (kg ha^{-1})

Significantly the highest seed yield of chickpea (1494 kg ha^{-1}) was obtained in Vaibhav variety, which was found to be significantly at par with RG 2009-01 (1448 kg ha^{-1}) and RG 2009-16 (1414 kg ha^{-1}) cultivars. The higher seed yield in cv. Vaibhav could likely be attributed to several factors, including a higher number of primary branches per plant, an increased number of pods per plant, a higher number of seeds per pod, and a higher 100-seed weight. These combined factors contributed to increased grain and biological yield, ultimately resulting in higher chickpea yields. This was in agreement with Shiva Kumar (2001) [28]. However, significantly the lowest seed yield was recorded in Jaki-9218 (1081 kg ha^{-1}) cultivar. Varietal differences in chickpea seed yield have been previously documented by Shamsi (2010) [26]. The significant variations in seed yield (kg/ha) among these varieties could be linked to distinct patterns of biomass allocation towards reproductive structures. Additionally, the significant differences in seed yield (kg/ha) among the varieties may be attributed to the fact that these varieties have diverse compensation mechanisms that directly impact seed yield. It's a valid point that varieties with longer growth durations tend to produce higher yields. Therefore, comparing varietal performance based on daily productivity, as suggested by Islam *et al.* (2010) [10], can provide a more meaningful criterion for evaluation, as it accounts for both the yield and the duration of growth. This approach can help in assessing a variety's efficiency in converting resources into yield over time.

Stover yield (kg ha^{-1})

The significantly highest stover yield was achieved by RG2009-01, with a recorded yield of 2200 kg ha^{-1}. This result was comparable to the stover yields of the next two highest-performing cultivars, namely Vaibhav with 2026 kg Kg ha^{-1} and JG-226 with 1922 kg ha^{-1}. The variety Jaki-9218, which is characterized by its short stature, recorded the lowest stover yield (1318 kg ha^{-1}). Similarly, Vishal had a stover yield of 1375 kg ha^{-1}, and Indira chana^{-1} produced 1593 kg ha^{-1} of stover, both of which were comparatively lower yields.

Harvest index (%)

Indeed, the harvest index is a crucial parameter in crop physiology. It holds significant importance as it reflects the allocation and translocation of dry matter within a given genotype, particularly focusing on how effectively resources are directed towards the economic or harvestable parts of the plant. This index is valuable for assessing the overall efficiency of a crop in converting resources into usable products, such as grains, which are of economic importance. The cultivar Vishal exhibited the significantly highest value of harvest index (45.30%), which was on par with Jaki-9218 (44.93%), RG 2009-16 (44.63%), JG-14 (43.82%), and Indira Chana-1 (43.77%). This suggests that these cultivars were efficient in allocating and trans locating dry matter towards their economic or harvestable parts. The lowest harvest index (HI) value was observed in the JG-226 cultivar of chickpea, recording 39.67%.

Protein content (%) in seed and stover

Significantly the highest protein content in seed was recorded with Indira chana^{-1} (21.56%) which was at par with JG-14, Vaibhav, JAKI-9218, RG2009-16, JG-130 and the lowest was recorded with JG-226 (19.42%). Whereas the protein content in stover of chickpea was found non-significant, however maximum numerical value was obtained with cultivar RG2009-01 (7.09%).The results are in conformity with works of Kushwaha *et al*. (2021) [17].

Table 1: Number of pods plant^{-1}, number of seeds pod^{-1}, seed index of different chickpea cultivars under organic production system

Cultivars	No. of pods plant^{-1}	Number of seeds pod^{-1}	Seed index (g)
V_1: JAKI-9218	37.33	1.19	22.50
V_2: RG2009-01	54.20	1.23	24.89
V_3: Vaibhav	56.20	1.21	24.32
V_4: RG2009-16	53.00	1.22	22.60
V_5: JG-130	47.70	1.20	22.93
V_6: Vishal	39.00	1.20	25.00
V_7: JG-226	43.27	1.23	24.35
V_8: Daftari-21	40.80	1.22	23.92
V_9: JG-14	45.57	1.24	22.33
V_{10}: Indira chana-1	43.23	1.27	22.95
S.Em ±	1.29	0.04	1.05

CD (P=0.05) 3.84, NS

Table 2: Seed yield, stover yield and harvest index (%) of different chickpea cultivars under organic production system.

Cultivars	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest Index (%)
V_1: JAKI-9218	1081	1318	44.93
V_2: RG2009-01	1448	2200	39.77
V_3: Vaibhav	1494	2026	42.29
V_4: RG2009-16	1414	1755	44.63
V_5: JG-130	1335	1870	42.53
V_6: Vishal	1148	1374	45.30
V_7: JG-226	1264	1922	39.67
V_8: Daftari-21	1191	1664	41.70
V_9: JG-14	1280	1639	43.82
V_{10}: Indira chana-1	1250	1593	43.77
S.Em ±	48.57	104.86	0.77
CD (P=0.05)	144.32	311.56	2.28

Table 3: Protein content (%) in seed and stover of different cultivars of chickpea under organic production system

Cultivars	Protein content (%)	
	Seed	Stover
V_1: JAKI-9218	20.48	6.33
V_2: RG2009-01	19.99	7.05
V_3: Vaibhav	21.09	6.30
V_4: RG2009-16	20.91	6.37
V_5: JG-130	21.17	6.43
V_6: Vishal	19.85	6.94
V_7: JG-226	19.42	6.65
V_8: Daftari-21	19.76	6.53
V_9: JG-14	21.23	6.84
V_{10}: Indira chana-1	21.56	6.85
S.Em±	0.38	0.31
CD (P=0.05)	1.14	NS

Conclusion

Based on the results, it can be inferred that each chickpea cultivar possesses its own unique qualities. However, when evaluating them in terms of yield potential, the Vaibhav, RG 2009-01, and RG 2009-16 cultivars emerged as the top-performing varieties. These cultivars demonstrated superior yield characteristics in the study. RG 2009-01 was also found to give highest stover yield. Two improved cultivars Vishal and RG 2009-16 yielded high with highest harvest index (45.30 and 44.63%). With respect to highest protein content (%) in seed for chickpea was recorded in the cultivar Indira chana-1 (21.56%). The lowest value of protein content (19.42%) was registered in JG-226.

As per the soil chemical properties such as pH, EC, Organic carbon and available NPK not significant affect by different cultivars of chickpea. Maximum gross return, net return and B: C ratio was obtained in Vaibhav, followed by RG2009-01.

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