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Effect of nutrient and weed management on yield attributes and yield of chickpea (*Cicer arietinum* L.) in *Vertisols* of Chhattisgarh

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Abstract
Field experiment was conducted at Instructional Farm, Dau Kalyan Singh College of Agriculture and Research Station, Bhatapara (C.G.). during *Rabi* season 2022-23. The experiment was laid out in split plot design with three replications. The treatment comprised of four nutrient management as main plot *viz.*, RDF (20:40:20) (N_1), RDF + Rhizobium (N_2), Rhizobium + PSB (N_3) with three weed management practices as sub plot *viz.*, weedy check (W_1), Pendimethalin 30 EC @ 1000 g a.i. ha^{-1} (PE) + Topramezone 33.6% SC @ 20.6 g a.i. ha^{-1} (PoE) (W_2) and weed free (W_3) check. Post harvest observations showed that nutrient management treatment RDF + Rhizobium + PSB (N_4) and weed management treatment weed free check (W_3) resulted in higher values for the number of pods, pod length, number of seeds per pod, 100-seed weight, seed yield, straw yield and biological yield.

Keywords: Chickpea, nutrient, PSB, rhizobium, weed management, yield

Introduction
Chickpea (*Cicer arietinum* L.) is commonly known as Bengal gram or *Chana*, belongs to Leguminosae. It is regarded as king of pulse. It contains 21.1% protein, 61.5% carbohydrate, 4.5% fat, vitamins and minerals. It is also rich in calcium, magnesium, iron, niacin, riboflavin, thiamin, folate and rich in unsaturated fatty acids like oleic and linoleic acid. Chickpea is classified in two categories i.e. Desi and kabuli. Desi gram is produced as 80% of total production whereas Kabuli gram contributes 20% of total production (Merga and Haji, 2019) [8].
India is the largest producer and consumer of chickpeas in the world, accounting for more than 65% of global production. The total chickpea area in India was 11.7 million hectares in 2020-21 (Anonymous, 2021) [2] with a production of 12.5 million metric tons. Madhya Pradesh, Maharashtra, Rajasthan, and Karnataka are the major chickpea producing states. The average chickpea productivity in India was 1,276 kg per hectare in 2020-21 (Anonymous, 2021) [2].
In Chhattisgarh, area under chickpea is of around 1.12 million hectares, accounting for about 10% of India's total chickpea area (Anonymous, 2021) [2]. The state is the 3rd largest chickpea producer in India after Madhya Pradesh and Maharashtra, with the production of 1.37 million metric tons in 2020-21 (Anonymous, 2021) [2]. However, Chhattisgarh's average chickpea productivity of 1,222 kg per hectare is lower than the national average of 1,276 kg per hectare, indicating scope for improvement (Anonymous, 2019) [1].
In chickpea production, one of the major constraints is weed infestation. Weeds compete with crop plants for space, water and nutrients and hence, it causes considerable yield losses. Thus, weeds are one of the major constraints to obtain high grain yield of improved crop cultivars if they are not controlled timely and properly. (Ratnam *et al.*, 2011) [13].
Manual weed control is labour intensive and therefore limits the production area (Dubey, 2014) [4]. Suitable herbicide (S) for effective control of mixed weed flora in chickpea is required (Singh and Jain, 2017) [14].

Materials and Methods
A field experiment was carried out during *Rabi* season, of 2022-23 at Instructional Farm, Dau Kalyan Singh College of Agriculture and Research Station, Alesur, Bhatapara (C.G.). The gross plot size was 5.4 m × 4 m, while the net plot size, where the actual experimentation occurred, was slightly smaller at 4.2 m × 3 m. In this experiment, there were 12 different treatments being tested, and each treatment was replicated thrice.

To maintain separation between replications, a gap of 1 meter was left between them, and a gap of 0.50 meters separated each individual plot. The Recommended Dose of Fertilizer (RDF) used was 20 kg N, 40 kg P_2O_5, and 20 kg K_2O per hectare. Chickpea variety RVG- 202 was timely sown, maintaining inter and intra row spacing of 30 cm and 10 cm respectively.

Results and Discussion

Number of pods: Number of pods plant^{-1} as influenced by various nutrient management and weed management practices of chickpea are presented in Table 1.

Nutrient management

Significantly maximum number of pods plant^{-1} (54.07) was found in treatment (RDF + Rhizobium + PSB) (N_4) which was at par with the treatment (RDF + PSB) (N_3) (47.08). Significantly minimum number of pods (19.71) was observed under RDF (N_1).

Table 1: Yield attributes of chickpea as influenced by nutrient and weed management.

Treatments	Number of pods plant^{-1}	Pod length (cm)	Number of grains pod^{-1}	100 seeds weight (g)
Nutrient Management (N)				
N_1: RDF (20:40:20 kg NPK ha^{-1})	19.71	1.35	1.51	20.90
N_2: RDF + Rhizobium	31.89	1.40	1.69	22.34
N_3: RDF + PSB	47.08	1.44	1.98	22.72
N_4: RDF + Rhizobium + PSB	54.07	1.48	2.44	22.83
S.Em±	2.27	0.004	0.12	0.13
CD (P=0.05)	7.87	0.015	0.43	0.46
Weed Management (W)				
W_1: Weedy check	34.88	1.39	1.78	22.06
W_2: Pendimethalin 30 EC @ 1000 g a.i. ha^{-1} (PE) +Topramezone 33.6% SC @ 20.6 g a.i. ha^{-1} (PoE)	37.84	1.42	1.88	22.07
W_3: Weed free check	41.83	1.44	2.05	22.48
S.Em±	0.82	0.006	0.07	0.10
CD (P=0.05)	2.45	0.017	0.21	0.30
Interaction (N×W)				
S.Em±	1.63	0.012	0.14	0.20
CD (P=0.05)	4.90	0.035	NS	0.60

Weed management

Significantly maximum number of pods plant^{-1} (41.83) was found under treatment W_3 (Weed free check) which was at par with the treatment (Pendimethalin 30 EC @ 1000 g a.i. ha^{-1} (PE) +Topramezone 33.6% SC @ 20.6 g a.i. ha^{-1} (PoE) (37.84) (W_2). Least number of pods (34.88) was observed in treatment (Weedy check) (W_1).

Interaction effect

Interaction effect of both the factors was significant for number of pods in chickpea. Applying higher levels of nutrients, especially phosphorus and nitrogen fertilizers along with Rhizobium and PSB, significantly increases the number of pods in chickpea plants. These nutrients and microbes promote better root and plant growth that supports formation of more pods. Likewise, effective weed management through herbicides or manual weeding creates less competition for nutrients, water and sunlight, allowing chickpea plants to produce more pods. The interaction between higher nutrient levels and weed free conditions resulted in the maximum number of pods per plant, showing that both adequate nutrients and weed control are important factors for boosting pod formation and yield. These outcomes are in line with findings of Patel and Thanki (2020) [11] and Singh & Yadav (2022) [15].

Pod length (cm)

Pod length **(**cm) influenced by various nutrient and weed management practices of chickpea are presented in Table 1.

Nutrient management

Significantly maximum pod length (1.48 cm) was found in treatment N_4 (RDF + Rhizobium + PSB) which was at par with RDF + PSB (N_3) (1.44 cm). Significantly minimum pod length (1.35 cm) was observed in treatment (RDF) (N_1).

Weed management

Significantly maximum pod length (1.44 cm) was recorded in treatment W_3 (Weed free check) which was at par with the treatment W_2 (Pendimethalin 30 EC @ 1000 g a.i. ha^{-1} (PE) +Topramezone 33.6% SC @ 20.6 g a.i. ha^{-1} (PoE) (1.42cm). Significantly minimum pod length (1.39 cm) was observed in treatment W_1 (Weedy check).

Interaction effect: Interaction effect of both the factors was significant for pod length in chickpea. Several factors influenced pod length in chickpea which impacts yield. Applying higher levels of nutrients especially phosphorus and nitrogen along with Rhizobium and PSB significantly increases pod length. These help in better vegetative growth, pod formation and filling of pods resulting in longer pods. Similarly, effective weed control through herbicides or manual weeding reduces competition for nutrients, water and light, allowing chickpea plants to produce longer pods. The interaction between adequate nutrient supply and weed free conditions resulted in the maximum pod length indicating that balanced nutrition and weed management are crucial for boosting both pod length and yield in chickpea. These outcomes are consistent with findings of Gupta *et al.* (2000) [6].

Number of grains pod^{-1}

Number of grains pod^{-1} was influenced by various nutrient management and weed management practices of chickpea are presented in Table 1.

Nutrient management: Significantly maximum (2.44) number of grains pod^{-1} was found in treatment N_4 (RDF + Rhizobium + PSB) which was at par with the treatment N_3 (RDF + PSB) (1.98). Significantly minimum number of grains pod^{-1} (1.51) was observed in treatment N_1 (RDF).

Weed management: Significantly maximum number of grains pod^{-1} (2.05) was recorded in treatment W_3 (Weed free check) which was at par with the treatment W_2 (Pendimethalin 30 EC @ 1000 g a.i. ha^{-1} (PE) + Topramezone 33.6% SC @ 20.6 g a.i. ha^{-1} (PoE) (1.88). Significantly minimum number of grains pod^{-1} (1.78) was observed in treatment W_1 (Weedy check). The highest number of seeds per pod was obtained with adequate nutrient supply and weed free conditions, showing that balanced nutrition and weed management play a key role in boosting both the number of seeds formed within each pod and the overall yield in chickpea. These outcomes corroborated the findings of Pramanik and Bera (2012) [12] and Panotra *et al.* (2012) [10].

100 seeds weight (g): The data on to 100 seeds weight (g) was influenced by various nutrient management and weed management practices of chickpea are presented in Table 1.

Nutrient management: The data pertaining 100 seeds weight was found significantly maximum (22.83 g) in treatment N_4 (RDF + Rhizobium + PSB) which was at par with the treatment N_3 (RDF + PSB) (22.72g). Significantly minimum 100 seed weight (20.90 g) was observed in treatment N_1 (RDF).

Weed management: Among the 100 seeds weight was found significantly higher (22.48 g) in treatment W_3 (Weed free check) which was at par with the treatment W_2 (Pendimethalin 30 EC @ 1000 g a.i. ha^{-1} (PE) + Topramezone 33.6% SC @ 20.6 g a.i. ha^{-1} (PoE) (22.07g). Significantly lower 100 seeds weight (22.06 g) was observed in treatment W_1 (Weedy check).

Interaction effect

Interaction effect of both the factors was significant for 100 seeds weight. Integrated nutrient and weed management markedly increased 100 seed weight. Rhizobium and PSB under N_4 offered optimum nutrition while pendimethalin and topramethalone in W_2 restricted weed competition enabling maximum resource utilization for seed filling and development. The weed free check showed highest seed weight due to competition free growth of crop. Gupta and Yadav (2022) [5] also reported similar finding.

Seed yield (kg ha^{-1}): Seed yield (kg ha^{-1}) of chickpea as influenced by various nutrient and weed management practices are presented in Table 2.

Nutrient management

Significantly maximum seed yield (1215.17 kg ha^{-1}) was obtained under (RDF + Rhizobium + PSB) (N_4) which was at par with the treatment (RDF + PSB) (N_3) (1071.28 kg ha^{-1}). Significantly lower seed yield (791.14 kg ha^{-1}) was recorded with RDF alone.

Weed management

Significantly higher seed yield (1275.14 kg ha^{-1}) was found in treatment W_3 (Weed free check) which was at par with the treatment W_2 (Pendimethalin 30 EC @ 1000 g a.i. ha^{-1} (PE) + Topramezone 33.6% SC @ 20.6 g a.i. ha^{-1} (PoE) (1204.28 kg ha^{-1}). Significantly lower seed yield (588.92 kg ha^{-1}) was observed in treatment W_1 (Weedy check).

Interaction effect

Interaction effect of both the factors was found significant for seed yield. Integrated nutrient and weed management sharply increased chickpea seed yield. Rhizobium and PSB under RDF + Rhizobium + PSB (N_4) offered optimum nutrition boosting yield attributes while pendimethalin and topramethalone in W_2 restricted weed competition enabling full expression of crop yield potential. The weed free check showed highest yield due to uninterrupted availability of resources for the crop and lack of competition from weeds throughout the crop cycle. These outcomes are similar to findings of Deva and Kohle *et al.* (2018) [3].

Straw yield (kg ha^{-1})

Straw yield (kg ha^{-1}) of chickpea influenced by various nutrient and weed management practices are presented in Table 2.

Nutrient management: Significantly maximum straw yield (2478.27 kg ha^{-1}) was found in treatment N_4 (RDF + Rhizobium + PSB) which was at par with the treatment N_3 (RDF + PSB) (2263.03 kg ha^{-1}). Significantly minimum straw yield (1278.95 kg ha^{-1}) was observed in treatment N_1 (RDF).

Weed management: Significantly maximum straw yield (2314.04kg ha^{-1}) was found in treatment W_3 (Weed free check) which was at par with the treatment W_2 (Pendimethalin 30 EC @ 1000 g a.i. ha^{-1} (PE) +Topramezone 33.6% SC @ 20.6 g a.i. ha^{-1} (PoE) (2183.39 kg ha^{-1}). Significantly lwer straw yield (1266.73kg ha^{-1}) was observed in treatment W_1 (Weedy check).

Table 2: Yield of chickpea as influenced by nutrient and weed management.

Treatments	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})
Nutrient Management (N)			
N_1: RDF (20:40:20 NPK kg ha^{-1})	791.14	1278.95	2070.08
N_2: RDF + Rhizobium	1013.53	1665.31	2678.83
N_3: RDF + PSB	1071.28	2263.03	3334.31
N_4: RDF + Rhizobium + PSB	1215.17	2478.27	3693.43
S.Em±	21.86	49.36	65.50
CD (P=0.05)	75.63	170.82	226.68
Weed Management (W)			
W_1: Weedy check	588.92	1266.73	1855.65

W_2: Pendimethalin 30 EC @ 1000 g a.i. ha^{-1} (PE) + Topramezone 33.6% SC @ 20.6 g a.i. ha^{-1} (PoE)	1204.28	2183.39	3387.67
W_3: Weed free check	1275.14	2314.04	3589.18
S.Em±	17.92	51.71	61.27
CD (P=0.05)	53.74	155.02	183.69
Interaction (N×W)			
S.Em±	18.05	1266.73	122.54
CD (P=0.05)	54.13	2183.39	367.38

Interaction effect

Interaction effect of both the factors was found significant for straw yield in chickpea. The higher straw yield in can be attributed to the synergistic effects of nutrient management, particularly treatment N_4 (RDF + Rhizobium + PSB), which optimized nutrient availability, and weed management, with treatment W_3 (Weed free check) reducing weed competition. These practices facilitated better plant growth and resource allocation, resulting in significantly increased straw production. The interaction effect of both factors also contributed to the higher straw yield. The weed free check showed the highest yield due to uninterrupted growth of crop and maximum dry matter production in straw with no competition from weeds. These outcomes corroborate the findings of Singh and Mukherjee (2002) [16].

Biological yield (kg ha^{-1})

Nutrient and weed management practices are found to have significantly influence on biological yield of chickpea (Table 2).

Nutrient management

Significantly higher biological yield (3693.43kg ha^{-1}) was found in treatment N_4 (RDF + Rhizobium + PSB) which was at par with the treatment N_3 (RDF + PSB) (3334.31 kg ha^{-1}). Significantly minimum biological yield (2070.08 kg ha^{-1}) was observed in treatment N_1 (RDF).

Weed management

Significantly higher biological yield (3589.18 kg ha^{-1}) was found in treatment W_3 (Weed free check) which was at par with the treatment W_2 (Pendimethalin 30 EC @ 1000 g a.i. ha^{-1} (PE) +Topramezone 33.6% SC @ 20.6 g a.i. ha^{-1} (PoE) (3387.67 kg ha^{-1}). Significantly lower biological yield (1855.65 kg ha^{-1}) was observed in treatment W_1 (Weedy check).

Interaction effect

Interaction effect of both the factors was found significant for biological yield in chickpea. The higher biological yield in chickpea is attributed to the optimal nutrient management practices, especially treatment N_4 (RDF + Rhizobium + PSB), and effective weed management, particularly treatment W_3 (Weed free check). These practices synergistically enhanced nutrient availability and reduced weed competition, leading to significantly increased biological yield. The interaction effect of both factors also contributed to the higher yield. The finding of present study is in accordance with those of Kumawat *et al.* (2013) [7].

Conclusions

Application of recommended dose of fertilizer combined with seed inoculation of rhizobium and PSB (N_4) recorded significantly higher number of pods plant^{-1} (54.07), pod length (1.48 cm), number of grain pod^{-1} (2.44) and seed weight (22.83 g) over RDF alone.

Application of RDF + rhizobium + PSB gave significantly higher yield over rest of the nutrient management practice. This treatment gave 117, 83 and 93% higher grain (1215 kg ha^{-1}) straw (2478 kg ha^{-1}) and biological yield (3693 kg ha^{-1}) respectively over RDF.

Among nutrient management practice weed free treatment recorded significantly higher number of pods plant^{-1} (41.83), 100 seed weight (22.48), seed yield (1275 kg ha^{-1}) and biological yield (3589 kg ha^{-1}). Pendimethalin 30 EC @ 20.6 g a.i. / ha (PoE) exhibited significantly higher seed yield (1204 kg ha^{-1}), straw yield (2183 kg ha^{-1}) and biological (3388 kg ha^{-1}) over unweeded check.

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