LR-5223
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RESEARCH ARTICLE
Legume Research- An International Journal

Effect of Sowing Dates and Seed Priming on Agrometeorological Indices and Soil Moisture Regimes of Chickpea in North Central Plateau Zone NCPZ of Odisha

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10.18805/LR-5223

ABSTRACT

Background: field experiment entitled "Effect of sowing dates and seed priming on agrometeorological indices and soil moisture regimes of Chickpea in NCPZ of Odisha" was conducted at RRTTS, Keonjhar, Odisha, during the *Rabi* season for two consecutive years *i.e.*, 2021-22 and 2022-23.

Method: The field experiment was laid out in factorial RBD design with three replications and two factors. There were 3 dates of sowing in Factor A (D_1-25 November, D_2-5 December, D_3- 15 December) and 5 moisture conservation practices in Factor B (M_1- Control, M_2- Seed priming with water for 8 hours, M_3- Osmopriming (Seed priming with $CaCl_2$ solution @0.5% for 8 hours), M_4- Straw mulch@ 5t/ha and M_5- Straw mulch@ 5t/ha +Seed priming with $CaCl_2$ solution @0.5% for 8 hours). Seed priming controls the hydration of seeds that helps in the pre germinative metabolic activity of the seeds. So even if the soil has less moisture that will not affect the uniform and proper germination of the seeds. All together there were 15 treatment combinations. The test crop variety taken was JAKI-9218. Among the three dates of sowing, D_2 (5th Dec) sowing recorded the tallest plants (41.47 cm). but were recorded in D_1 (25 Nov) sowing. Early sowing on 25th November recorded the maximum number of primary and secondary branches and required a greater number of days to 50% flowering (41.8 days) and days to physiological maturity (101.1 days).

Results: Among the moisture conservation practices, M_5 (Straw mulch@ 5 t/ha+Seed priming with $CaCl_2$ solution @ 0.5% for 8 hours) recorded the tallest plants, maximum number of primary and secondary branches, maximum number of days taken to 50% flowering (40.7 days) and days taken to physiological maturity (100.1 days), maximum number of pods per plant (44) and number of seeds per pod (3.62), grain yield (1812 kg/ha) and straw yield (218 kg/ha). This treatment recorded the minimum consumptive use of water (203.5 mm) and rate of moisture use (1.36 mm/day) but the moisture use efficiency was maximum (12.34 kg/ha-mm). Treatment M_5 recorded the maximum growing degree days (2182°C day), heliothermal unit (15077°C day hrs), photothermal unit (22595°C day hrs) and heat use efficiency (0.94 kg/ha/°C) to reach maturity. Chickpea when combined with suitable date of sowing and moisture conservation practices for proper utilization of carry-over residual soil moisture in the rice fallows gives higher yield.

Key words: Dates of sowing, GDD, Moisture use efficiency, Seed priming, Sraw mulch.

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is the third most important pulse crop in the world, with 14.84 million hectares in cultivation, 15.08 million tons produced and an average yield of 1.01 t/ha (all numbers from FAOSTAT, 2021). It is one among India's most important Rabi pulse crops. Chick pea farming covers 105.61 million hectares (ha), yields 112.29 million tons (t) and yields 1063 kilograms per hectare (kg/ha) in India (Samriti *et al*., 2020). It is often grown in the winter on fallow fields where soil moisture has been kept following the harvest of *kharif* paddy. According to research, the best sowing period for chickpeas has a substantial impact on both yield and quality. The time of seeding has a substantial effect on chickpea yield and quality (Ali *et al*., 2018). When the sowing timing is perfect, the plant has plenty of time to grow and mature, which improves yield. Flowering at a time when frost is unlikely is also beneficial in terms of crop protection (Chopada *et al*., 2016). Early or late seeding reduces growth and development, which both diminish yield (Husnain *et al*., 2015). Early seeding yields a lesser yield because fewer pods and seeds develop.

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How to cite this article: Ray, M., Roul, P.K., Kapoor, P., Yadav, S., Supriya, Kumari, N. and Mishra, P. (2024). Effect of Sowing Dates and Seed Priming on Agrometeorological Indices and Soil Moisture Regimes of Chickpea in North Central Plateau Zone NCPZ of Odisha. Legume Research. doi: 10.18805/LR-5223.

Submitted: 04-08-2023 **Accepted:** 23-01-2024 **Online:** 14-03-2024

Late sowing affects crop output due to the shorter time for seed development (Girma *et al*., 2017; Mubvuma *et al*., 2015). Crop output decreased by 28% for every 10 days if crop sowing was postponed (Ray *et al*., 2017). The single most important element in influencing chickpea production is sowing date, making it a critical non-monetary input.

About 30% of the area remains fallow after the harvest of rice in Eastern India (Hazra and Bohra, 2020). During the rabi season due to the lack of irrigation facilities, the growing of crop depends on the effective utilization of the carry-over residual moisture of the previous crop. (Narendra *et al*., 2012). Approximately 70 per cent of the chickpea in India is grown under rainfed conditions (Choudhary *et al*., 2016). As chickpea has an indeterminate growth habit, the yield accumulation depends on continuous and simultaneous vegetative and reproductive development starting from the commencement of flowering, therefore the moisture availability during all the growth stages is also one of the important factors for higher potential yield (Asaf *et al*., 2023). Chickpea in Odisha is usually grown on stored or residual soil moisture after the harvest of *kharif* paddy and mostly faces moisture stress throughout its life cycle which drastically reduces the yield. Moisture stress affects the nitrogen fixation of chickpea crop, its uptake and assimilation. Nitrogen fixation isbreduced due to a reduction in leghaemoglobin in the nodules, specific activity of nodule and in the number of nodules. In the rainfed areas, out of whatever little rainfall that is received during the season,not all is available to the crops, but a major part of it is lost as run off and evaporation. Therefore, intensive efforts are required to develop soil and moisture conservation practices to attenuate the moisture stress so that the food production can be maximized with minimal environmental degradation. The solution to this problem is adoption of in-situ moisture conservation practices (Kumar *et al.,* 2008; Rathore *et al.,* 2010). The adoption of eco-friendly and economical techniques such as seed priming and in situ application of crop residues are of vital importance (Rakshit and Singh, 2018; Sarkar *et al.*, 2020). Seed priming ensures vigorous and uniform germination of the seeds, good crop stand and enables the crop to mitigate the biotic and abiotic stresses and improves the quality of the produce(Paparella *et al*., 2015; Chatterjee *et al*., 2018; Zulfiqar, 2021) and enhances yield potential (Marthandan *et al*., 2020). In situ application of crop residues helps to conserve more rain water in soil by reducing the runoff of water from the soil surface andloss of water through evaporation under water scarcity situations (Singh *et al.,* 2013; Paliwal *et al.,* 2011). They also help to balance and regulate the soil profile temperature (Hari Ram *et al.,* 2012).

MATERIALS AND METHODS

A field experiment entitled “Effect of sowing dates and seed priming on agrometeorological indices and soil moisture regimes of Chickpea in NCPZ of Odisha” was conducted at Experimental Block of Regional Research and Technology Transfer Station, Keonjhar, Odisha, India during the Rabi season for two consecutive years *i.e*., 2021-22 and 2022-23. The field experiment was laid out in factorial RBD design with three replications and two factors, the first one being the dates of sowing (Factor A) and the second one being moisture conservation practices (Factor B). There were 3 dates of sowing in Factor A (D_1-25 November, D_2-5 December, D_3- 15 December) and 5 moisture conservation practices in Factor B (M_1- Control, M_2- Seed priming with water for 8 hours, M_3- Osmopriming (Seed priming with $CaCl_2$ solution @0.5% for 8 hours), M_4- Straw mulch@ 5 t/ha and M_5- Straw mulch@ 5 t/ha +Seed priming with $CaCl_2$ solution @0.5% for 8 hours). Altogether there were 15 treatment combinations. The test crop variety taken was JAKI - 9218. The crop was sown with a row spacing of 30 cm as per the dates of sowings. Fertilizers were applied on a soil test basis. A dose of 20 kg N, 40 kg P_2O_5 and 40 kg K_2O/ha was applied to all plots as a basal dose just below the seed at the time of sowing. N and P_2O_5 were applied through urea and single SSP and given as basal. Two irrigations were given, 5 cm each, one at pre flowering stage and the other at pod-formation stage coinciding with the critical stages of crop growth during both the years of experimentation. The amount of rainfall received during the crop growth period of chickpea was 87.4 mm (25^{th} Nov sowing), 85.2 mm (5^{th} Dec sowing) and 40.8 mm (15^{th} Dec sowing) during the year 2021-22 whereas in the year 2022-23, the crop did not receive any rainfall during its growth period. All recommended packages of practices were followed for cultivation as per the treatments.

Observations recorded

Morphological characters

The observations of plant height, as well as the number of primary and secondary branches, were documented in accordance with the established protocol for five identified plants inside the designated plot. The phenological parameters, specifically the days to flower initiation, days to fifty percent blossoming, days to pod initiation and days to maturity, were recorded in a random manner within the plot and were expressed in terms of days.

Yield attributes and yield

Yield attributes were recorded from the five-plant sample collected at the time of harvest. The crop harvested from net plot area was converted into seed yield (kg/ha) and straw yield (kg/ha).

Moisture use indices

The temperature of soil is directly linked to the temperature of the atmosphere because soil is an insulator for heat flowing between the solid earth and the atmosphere.12 cm up from the tip of the soil thermometer was measured and the spot was marked and a hole was made. The soil thermometer was inserted through the spacer. 12 cm of the thermometer was sticking out of the bottom of the spacer and it was labelled to 10 cmand then then the soil temperature was measured.

Consumptive use of water was calculated by adding up the contribution of soil moisture and effective rainfall. Effective rainfall was measured by dividing the potential evapotranspiration by precipitation received (PET/P) (Dastane, 1974). Grain yield of chickpea was divided by the total consumptive use of water. To find out the moisture use efficiency.

Thermal indices

Following the method proposed by Monteith (1984), we tallied the daily mean temperature increments over the base temperature for the appropriate time intervals after sowing to determine the number of growing degree days for each phenological stage.

$$GDD = \Sigma \frac{(Tmax + T\ min)}{2} - \ T\ base$$

Where:
Tmax, Tmin= Maximum, minimum temperature.
T base= Base temperature taken as 5°C.

Helio thermal unit (HT)

Aids in evaluating crop responses to ambient temperature through phenological phases by effectively factoring in and expressing the effect of varying ambient temperature on the duration of the occurrences. Rajput's formula from 1980 was used to determine the helio thermal unit.

HTU =

$$GDD \times \text{Cumulative Sun Shine Hours (from sowing to physiological maturity)}$$

Photothermal units (PTU)

PTU is calculated by multiplying cumulative growing degree days with day length that were obtained on a daily basis. Day length was estimated by calculating the sun rise and sun set (Dhaliwal *et al*., 2007).

$$PTU = GDD \times \text{Day length}$$

Heat use efficiency was calculated as:

$$HUE = \frac{\text{Total dry matter (g m}^2)}{GDD}$$

RESULTS AND DISCUSSION

Growth parameters

Among the three dates of sowing, D_2 (5th Dec) recorded the tallest plants (41.47 cm) which was significantly different from the rest two dates of sowing. The shortest plants were recorded in D_3 (15th Dec) sowing (39.60 cm). Among the 5 moisture conservation practices, M_5 (Straw mulch@ 5t/ha +Seed priming with $CaCl_2$ solution @ 0.5% for 8 hours) recorded the tallest plants (43.98 cm) which were at par with M_4 (Straw mulch@ 5 t/ha) (43.61 cm) and statistically superior to the rest of the treatments (Table 1).

Maximum number of primary and secondary branches were observed with chickpea sown on 25th Nov (3.47 and 8.90) respectively, which was statistically superior to the other sowing dates. Among the nutrient management practices the maximum number of primary and secondary branches were recorded in M_5, closely followed by M_4 and M_3.

Table 1: Effect of sowing dates and moisture conservation practices on growth parameters of chickpea.

Treatments	Plant height (cm)	Primary branches	Secondary branches	Days to 50% flowering	Days to physiologic almaturity
Dates of sowing					
D_1 (25th Nov)	40.56	3.47	8.9	41.8	101.1
D_2 (5th Dec)	41.47	3.01	5.75	39.5	94.4
D_3 (15th Dec)	39.6	2.96	7.64	37.6	87.2
SE(m)	0.28	0.12	0.15	0.08	0.14
CD (P=0.05)	0.82	0.42	0.51	0.27	0.47
Moisture conservation practices					
M_1- Control	36.82	2.99	7.06	36.2	89.8
M_2- Seed priming with water for 8 hours	38.08	3.15	7.43	37.9	91.8
M_3- Osmopriming (Seed priming with $CaCl_2$ solution @ 0.5% for 8 hours)	37.37	3.26	8.72	38.2	92.3
M_4- Straw mulch@ 5 t/ha	43.61	3.29	9.80	40.2	98.9
M_5- Straw mulch@ 5 t/ha +Seed priming with $CaCl_2$ solution @ 0.5% for 8 hours	43.98	3.55	9.89	40.7	100.1
SE (m)	0.64	0.14	0.40	0.15	0.36
CD (P=0.05)	1.80	0.54	1.12	0.55	0.99
Interactions (G×D)					
SE (m)	1.23	0.90	0.66	0.31	0.60
CD (P=0.05)	NS	NS	1.99	0.92	1.72

(Pooled data for the year 2021-22 and 2022-23).

The results revealed that delay in sowing of the chickpea crop significantly affected the days to flowering and to maturity. It was observed that the maturity date decreased with delay in sowing. Early sowing on 25th November required a greater number of days to 50% flowering (41.8 days) and days to physiological maturity (101.1 days) of chickpea. The minimum days taken to 50% flowering (37.6 days) and days taken to physiological maturity (87.2 days) were recorded with 15th December sowing. There is a reduction in the time taken to 50% flowering and time taken to physiological maturity due to the high temperature coinciding with the vegetative growth stage. Similar results were reported by Ali *et al.*, (2018).

Among the moisture conservation practices the maximum number of days taken to 50% flowering (40.7 days) and days taken to physiological maturity (100.1 days) were recorded when straw mulch was applied @ 5t/ha +Seed priming of chickpea seeds was done with $CaCl_2$ solution @ 0.5% for 8 hours (M_5). This treatment was followed by treatments M_4 and M_3. The minimum days taken to 50% flowering (36.2 days) and days taken to physiological maturity (89.8 days) were recorded when no moisture conservation treatments were given (M_1).

Yield and yield attributes

Table 2 shows that as the planting date of chickpeas is pushed back, the plant yield, seed yield and grain yield all decline. Sowing on November 25th resulted in the highest pod count per plant (43), seed count per pod (3.36) and grain yield (1832 kg/ha). A prolonged grain-filling period due to moderate temperatures during the grain-filling stage may account for the higher grain production of early seeded chickpeas (Rehman *et al*., 2015; Ray *et al*., 2020). The 15th of December seeding produced the fewest pods per plant (37), seeds per pod (2.03) and grain yield (1401 kg/ha). A decrease in chickpea pods per plant, seeds per pod and grain output may result from delayed seeding if high temperatures occur during blooming and low temperatures occur during fertilization. The literature on this topic is extensive (Sharma and Sharma, 2002; Sethi *et al*., 2018; Kumar *et al*., 2021). Sowing on the 5th of December resulted in the highest stover output (202 kg/ha), followed by sowing on the 25th of November. Sowing on the 15th of December resulted in the lowest stover production (155 kg/ha).

Among the moisture conservation practices, the treatments where straw mulch was applied gave better results than the other treatments. The maximum number of pods per plant (44) and number of seeds per pod (3.62), grain yield (1812 kg/ha) and straw yield (218 kg/ha) of chickpea was recorded with treatment M_5 (Straw mulch@ 5 t/ha +Seed priming with $CaCl_2$ solution @ 0.5% for 8 hours) which was at par with treatment M_4 (Straw mulch@ 5 t/ha). Treatment M_1(control) recorded the least values. Moisture present in the soil is the most important factor that influences the growth of chickpea plants right from the establishment of the seedling till its maturity. Therefore, moisture stress during the life cycle of the crop might be the reason for less yield in the controlled plot where no moisture conservation practices were adopted.

Interaction effects of sowing time and moisture conservation practices on number of pods per plant and

Table 2: Effect of sowing dates and moisture conservation practices on yield and yield attributes of chickpea.

Treatments	No. of pods per plant	No. of seeds per pod	Grain yield (Kg/ha)	Straw yield (Kg/ha)
Dates of sowing				
D_1 (25th Nov)	43	3.36	1832	174
D_2 (5th Dec)	40	2.64	1495	202
D_3 (15th Dec)	37	2.03	1401	155
SE (m)	0.32	0.15	17.86	0.02
CD (P=0.05)	0.99	NS	50.29	0.08
Moisture conservation practices				
M_1- Control	35	2.77	1499	157
M_2- Seed priming with water for 8 hours	38	2.96	1693	178
M_3- Osmopriming (Seed priming with $CaCl_2$ solution @ 0.5% for 8 hours)	40	3.01	1699	182
M_4- Straw mulch@ 5 t/ha	42	3.27	1723	199
M_5- Straw mulch@ 5 t/ha+Seed priming with $CaCl_2$ solution @ 0.5% for 8 hours	44	3.62	1812	218
SE (m)	0.32	0.16	39.9	4.02
CD (P=0.05)	0.99	0.49	113.4	13.09
Interactions (G×D)				
SE (m)	0.56	0.38	57.1	7.05
CD (P=0.05)	NS	NS	175.6	23.17

(Pooled data for the year 2021-22 and 2022-23).

number of seeds per pod were non-significant whereas it was significant with grain yield and straw yield of chickpea (Table 2).

Soil profile temperature

Among the three dates of sowing, there was no significant difference with regard to the soil profile temperature.

The soil profile temperature was increased significantly in the plots where the straw mulch was applied on the surface of the soil as a moisture conservation practice in comparison to the plots where only seed priming was done before sowing the seeds and the control plot (Table 3). The loss of heat from the soil profile to the atmosphere might have been prevented due to the application of straw mulch on the surface of the soil and also high moisture content might have been maintained in the soil which in turn helped in increasing the temperature of the soil during the winter season because of higher specific heat (Hari Ram *et al.,* 2012). Similar results were reported by Choudhary *et al*. (2016).

Moisture use indices

Chickpea sown on third date *i.e.*, on 15th Dec recorded the maximum consumptive use of water (414.4 mm) and rate of moisture use (1.53 mm/day) followed by 5th Dec sowing (208.7 mm and 1.49 mm/day) and 25th Nov Sowing (204.2 mm and1.46 mm/day respectively). The moisture use efficiency was the maximum on the first date of sowing (12.44 kg/ha-mm) and was statistically superior to the rest of the two dates of sowing.

Among the moisture conservation practices the plots where straw mulch was applied recorded lesser values of consumptive use of water and rate of moisture use by chickpea in comparison to the rest of the plots. Treatment M_5 (Straw mulch@ 5 t/ha +Seed priming with $CaCl_2$ solution @ 0.5% for 8 hours) recorded the minimum consumptive use of water (203.5 mm) and rate of moisture use (1.36 mm/day) which was comparable to M_4 (Straw mulch@ 5t/ ha) (205.9 mm and 1.38 mm/day) and M_3 (Osmopriming-Seed priming with $CaCl_2$solution @ 0.5% for 8 hours) (206.2 mm and 1.39 mm/day) respectively. Maximum consumptive use of water and rate of moisture use was recorded in the controlled plot (215.7 mm and 1.50 mm/day respectively). Maximum moisture use efficiency was recorded in Treatment M_5 (12.34 kg/ha-mm) which was significantly superior to the rest of the moisture conservation practices. Treatment M_4 and M_3 closely followed treatment M_5. Moderate soil thermalregime and greater soil moisture retention under straw-applied treatments resulted in higher grain yield, thereby reducing the water use which in turn increased the water use efficiency and decreased the rate of moisture use (Mishra *et al.,* 2012; Choudhary *et al*., 2016).

Thermal indices

Among the different sowing dates, the crop sown on 25th November recorded the maximum growing degree days (2113°C day), heliothermal unit (15081°C day hrs), photothermal unit (24177°C day hrs) and heat use efficiency (0.89 kg/ha/°C) to reach maturity followed by 5th December sowing. Early sown crops require more heat units to reach maturity than late-sown crop (Suryakala *et al*., 2020). This might be due to longer crop duration of the crop recorded with early sowing and the incidence of higher temperature during the vegetative stage and moderate temperature during the grain filling stage of the crop. These findings are in conformity with those of Gan *et al*. (2002); Singh *et al*.,

Table 3: Effect of sowing dates and moisture conservation practices on soil profile temperature (0-15cm soil depth) and moisture use indices ofchickpea.

Treatments	Soil profile temperature (°C)	Consumptive use of water (mm)	Moisture use efficiency (kg/ha-mm)	Rate of moisture use (mm/day)
Dates of sowing				
D_1 (25th Nov)	23.3	204.2	12.44	1.46
D_2 (5th Dec)	23.6	208.7	10.74	1.49
D_3 (15th Dec)	23.1	214.4	8.63	1.53
SE(m)	0.54		0.302	0.002
CD(P=0.05)	NS		1.007	0.006
Moisture conservation practices				
M_1 - Control	23.6	215.7	7.63	1.50
M_2 - Seed priming with water for 8 hours	23.1	210.7	9.82	1.41
M_3 - Osmopriming (Seed priming with $CaCl_2$ solution @ 0.5% for 8 hours)	23.7	206.2	9.64	1.39
M_4 - Straw mulch@ 5 t/ha	24.1	205.9	11.54	1.38
M_5 - Straw mulch@ 5 t/ha +Seed priming with $CaCl_2$ solution @ 0.5% for 8 hours	24.5	203.5	12.34	1.36
SE(m)	0.21		0.173	0.001
CD(P=0.05)	0.72		0.542	0.003

(Pooled data for the year 2021-22 and 2022-23).

Table 4: Effect of sowing dates and moisture conservation practices of chickpea on agro meteorological indices.

Treatments	Growing degree days (GDD) °C	Heliothermal units (HTU °C day hrs)	Photothermal units (PTU °C day hrs)	Heat use efficiency (HUE kg/ha/°C)
Dates of sowing				
D_1 (25th Nov)	2113	15081	24177	0.89
D_2 (5th Dec)	1955	14552	22104	0.79
D_3 (15th Dec)	1831	14263	20881	0.64
SE (m)	2.52	21.72	29.25	0.010
CD (P=0.05)	7.11	61.20	82.42	0.033
Moisture conservation practices				
M_1- Control	1816	13885	21114	0.65
M_2 - Seed priming with water for 8 hours	1897	14346	21422	0.75
M_3- Osmopriming (Seed priming with $CaCl_2$ solution @ 0.5% for 8 hours)	1911	14433	21783	0.81
M_4- Straw mulch@ 5 t/ha	2031	14605	22097	0.86
M_5- Straw mulch@ 5 t/ha+Seed priming with $CaCl_2$ solution @ 0.5% for 8 hours	2182	15077	22595	0.94
SE (m)	5.7	48.5	65.5	0.03
CD (P=0.05)	16.6	137.1	185.2	0.08
Interactions (G×D)				
SE (m)	9.8	84.1	113.2	0.02
CD (P=0.05)	27.9	236.1	319.2	0.07

(Pooled data for the year 2021-22 and 2022-23).

(2008); Agrawal and Upadhyay, (2009) and Medida *et al*. (2020). Minimum growing degree days, heliothermal unit, photothermal unit and heat use efficiency was recorded with 15th December sowing (1831°C day, 14263°C day hrs, 20881°C day hrs and 0.64 kg/ha/°C) respectively (Table 4). Late sown chickpeas accumulated fewer heat units as they were exposed to the suboptimal thermal regime which led to a decrease in heat use efficiency. These are in line with the findings of Agrawal *et al*., (2002); Agrawal and Upadhyay, (2009).

Among the different soil moisture conservation practices Treatment M_5 recorded the maximum growing degree days (2182°C day), heliothermal unit (15077°C day hrs), photothermal unit (22595°C day hrs) and heat use efficiency (0.94 kg/ha/°C) to reach maturity closely followed by treatment M_4. Treatment M_1(control) recorded the minimum heat units to reach maturity.

CONCLUSION

Based on the results of two years of experimentation it can be concluded that early sowing of chickpeas along with the application of straw mulch@ 5 t/ha + Seed priming with $CaCl_2$ solution @0.5% for 8 hours is recommended for achieving higher productivity of chickpea crop in North Central Plateau Zone of Odisha.

Funding

No funding.

Conflict of interest

The authors declare no competing interests.

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