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RESEARCH ARTICLE

# Weed competitive ability and productivity of transplanted rice cultivars as influenced by weed management practices

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**ABSTRACT**

Weed competitive ability of six rice cultivars including three hybrids [Arize 6129 (short duration); Arize 6444 (medium duration), Arize Dhani (long duration)] and three varieties [Swarna Shreya (short duration); Rajendra Sweta (medium duration); MTU 7029 (long duration)] was evaluated under three weed pressures *i.e.* low weed pressure [pre-emergence application (PE) of pretilachlor 0.60 kg/ha at 2 days after transplanting (DAT) followed by *(fb)* post-emergence application (PoE) of bispyribac-sodium 30 g/ha at 20 DAT *fb* 1 hand weeding (HW) at 35 DAT; medium weed pressure (pretilachlor PE at 2 DAT *fb* bispyribac-sodium PoE at 20 DAT) and high weed pressure (weedy check)]. Experiment was conducted during rainy seasons of 2018 and 2019 at the ICAR-Research Complex for Eastern Region Patna, Bihar. The major weeds recorded with transplanted rice were *Brachariaria ramosa, Trianthema portulacastrum, Cyperus rotundus, Echinochloa colona, Caesulia axillaris* and *Physalis minima*. Rice hybrids, *viz.* Arize 6444 and Arize Dhani, and rice variety Swarna Shreya recorded significantly lower weed biomass compared to other varieties. Weeds reduced rice grain yield by 31.37%. Long-duration and short statured rice variety MTU 7029 was more susceptible to weed competition compared to other varieties and hybrids. Early duration hybrid Arize 6129 recorded low weed pressure, maximum rice grain yield (6.57 t/ha) and economic returns.

**Keywords:** Cultivars competitiveness, Hybrids, Rice, Varieties, Weed management

## INTRODUCTION

Weeds are one of the major constraints in transplanted rice in drought-prone environments. Weeds compete with rice for moisture, nutrients, light, and space, and as a consequence result in yield loss ranging from 20-60% depending on the nature and density of weed species, and management practices (Rao *et al*. 2017). Farmers do follow certain weed management practices (manual, mechanical, herbicides, *etc*.) to minimise the weed infestation in crop fields. However, weeds are so complex and diverse in rice fields that no single method can control them effectively. Manual weeding is the most common method to suppress weeds in rice but scarcity of labour for timely weeding and high labour cost are major limitations (Mishra *et al.* 2022). The herbicidal weed management offers better weed control, but it may lead to environmental hazards. Moreover, weeds germinate in several flushes especially during rainy season, and may not be controlled satisfactorily using only herbicides. In such conditions, use of weed competitive cultivars as a component of integrated weed management system would be highly economical and eco-friendly. Rice verities vary in their weed competitive ability due to their diverse morphological traits, *viz*. plant height, tillering ability, canopy structure and relative growth rate, *etc*. (Ramesh *et al*. 2017; Kumar *et al.* 2020). Weed competitive cultivars are characterized by higher early vigour, higher leaf-area and biomass accumulation, rapid ground cover by canopy, deep and prolific roots, more tillering ability, taller plant, early maturity and allelopathy (Caton *et al*. 2003; Dhillon *et al*. 2021). A quick growing and early canopy cover enables a cultivar to compete better against weeds. Tall cultivars of rice exert effective smothering effect on weeds. Duration of the rice varieties also influences the crop-weed competition. Early maturing rice cultivars and hybrids have smothering effect on weeds due to improved vigour and having the tendency of early canopy cover (Mandal *et al.* 2011). In drought-prone environments,

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short duration rice cultivars may have high weed competitive ability over longer duration cultivars. However, the weed suppressing ability of rice cultivars may vary under different weed management practices. Therefore, the present study evaluated the weed competitive ability of rice cultivars under different levels of weed management in transplanted rice in the middle Indo-Gangetic Plains (IGP).

## MATERIALS AND METHODS

The present study was carried out at the ICAR-Research Complex for Eastern Region, Patna, Bihar (25°30’N, 85°15’E, 52 m above mean sea levels) during 2018 and 2019. Total rainfall received during cropping season (June–October) was 715.7 and 911.5 mm in 2018 and 2019, respectively. Soil was clay loam (42% sand, 35% silt and 23% clay), low in organic carbon (0.46%), and N (212 kg/ha), and medium in available phosphorus (26 kg P/ha) and potassium (215 kg K/ha). Experiment was laid out in a split-plot design with three replications. The main plot consisted of three weed pressure maintenance treatments includes low weed pressure maintained with pre-emergence application (PE) of pretilachlor 0.60 kg/ha at 2 days after transplanting (DAT) followed by (*fb*) post-emergence application (PoE) of bispyribac-sodium 30 g/ha at 20 DAT followed by (*fb*) hand weeding (HW) at 35 DAT; medium weed pressure maintained with pretilachlor 0.60 kg/ha PE at 2 DAT *fb* bispyribac-sodium 30 g/ha PoE at 4-6 leaf stage *i.e*. 20 DAT, and high weed pressure maintained as weed check. Six high yielding rice cultivars including 3 hybrids [Arize 6129 (short duration: 115-120 days), Arize 6444 (medium duration: 130-135), Arize Dhani (long duration: 150-155)] and three varieties [Swarna Shreya (short duration: 115-120 days), Rajendra Sweta (medium duration: 130-135), MTU 7029 (long duration: 145-150)], were kept in sub plots. Herbicides were sprayed with knap-sack sprayer fitted with flat-fan nozzle using 500 litres/ha spray volume. Recommended dose of fertilizer (120, 60, 40 and 5 kg/ha N, P, K and Zn) was applied. Total quantity of P, K and Zn was applied as basal, whereas nitrogen was applied in 3-equal split-each at basal, maximum tillering and panicle initiation. There were large variations in rainfall intensity and distribution patterns during the experimentation. Average of mean rainfall during rice season (June–October) was 715.7 mm and 911.5 mm in 2018 and 2019, respectively. During 2018, crop faced early and late-season drought during cropping periods, but during 2019, rainfall was distributed quite uniformly. Mean monthly maximum and minimum temperature ranged between 28.7-37.4 and 16.1-28.2°C during 2018 and 2019, respectively. Leaf-area index (LAI) was measured at 60 DAS by removing all the leaves from each of 5 randomly selected plants from each plot and passing them individually through a stationary leaf area meter (Model: LI-COR 310).

Weed density and biomass were recorded at 60 DAT using a quadrat (0.5 × 0.5 m) placed randomly at 4 places in each plot. Weeds within each quadrat were uprooted, separated species wise and counted. Weed samples were oven dried before weighing at 70°C till constant weight was achieved. Data on weed density were subjected to square root transformation ($\sqrt{x+0.5}$) before statistical analysis to normalize their distribution. Data were analyzed statistically as per standard method (Panse and Sukhatme 1978). Test of significance of treatment differences was done on the basis of t-test. Significant difference between treatments mean was compared with critical differences at 5% levels of probability.

## RESULTS AND DISCUSSION

### Effect on weeds

The experimental field was infested with grasses (19.8%), broad-leaved weeds (67.26%) and sedges (12.93%). Among grassy weeds, *Brachiaria ramosa* (10.44%) was dominant followed by *Echinochloa colona* (8.63%). *Trianthema portulacastrum* (58.02%) was the major broad-leaved weed and *Cyperus rotundus* (8.9%), the major sedge. Other weeds contributed 3.69%.

Weed management practices and rice cultivars significantly influenced the weed flora density and biomass (**Table 1** and **2**). Irrespective of the weed species, pretilachlor *fb* bispyribac-sodium *fb* 1 HW at 35 DAT resulted in significantly lower total weed density and biomass. In general, hybrids were more competitive against weeds than the varieties, but the response varied with weed species. The density and biomass of *B. ramosa* was significantly lower in association with Arize 6444 than in Rajendra Sweta. Among rice varieties, Swarna Shreya was more competitive than the other two varieties. The density of *T. portulacastrum* was significantly lower in ‘Arize 6444’ as compared to long duration rice variety MTU 7029 (56.65/m$^2$). The density and biomass of *C. rotundus*, *E. colona* and *C. axillaris* did not vary significantly due to rice cultivars. Total weed density and biomass was significantly lower with rice hybrid Arize 6444 compared to long duration rice variety MTU 7029. Among hybrids, Arize Dhani being on a par with Arize 6444 and among varieties, Swarna Shreya registered the lowest weed biomass. This might be due to taller plant height and higher leaf area index resulting in better weed suppression. Kumar (2018) and Kumar *et al.* (2016) also reported that tall statured genotypes with drooped leaves were found to be more competitive than short and erect leaved genotypes. Better weed suppressing ability of hybrid rice over open-pollinated varieties was also reported by Awan *et al.* (2018).

### Effect on rice

Crop growth, yield attributes and grain yield were significantly influenced by weed management practices and cultivars (**Table 3**). In general, higher grain yield of rice was recorded during 2019 as compared to 2018 due to sufficient and evenly distributed rainfall during 2019 (911.5 mm) compared to 2018 (715.7 mm). Uncontrolled weeds (high weed pressure) reduced rice grain yield by 31.37% as compared to low weed pressure. Maintaining low weed pressure with pretilachlor PE *fb* bispyribac-sodium PoE *fb* 1 HW at 35 DAT recorded significantly higher growth and yield attributes and grain yield of rice due to lesser crop-weed competition, followed by medium and high weed pressure treatments which can be attributed to lesser crop-weed competition for nutrients and moisture supply, resulting in maximum use of inputs for crop growth, yield attributes and yield. Maximum plant height, leaf area index, dry matter/hill was recorded with rice hybrid Arize 6444 but number of tillers/m$^2$ was higher with Arize 6129. Panicle length in all the 3 hybrids (24.3-24.9 cm) was at par with rice variety Swarna Shreya (24.6 cm), but significantly higher than Rajendra Sweta (20.6 cm) and MTU 7029 (22.5

**Table 1. Weed density (no./m$^2$) at 60 DAT as influenced by rice cultivars and weed management treatments in transplanted rice (pooled data of 2 years)**

| Treatment | *Brachariaria ramosa* | *Trianthema portulacastrum* | *Cyperus rotundus* | *Echinochloa colona* | *Caesulia axillaris* | *Physalis minima* | Others weeds | Total weed density |
|---|---|---|---|---|---|---|---|---|
| *Weed management practices* | | | | | | | | |
| Low weed pressure | 2.63 (6.4) | 4.82 (22.9) | 3.00 (8.7) | 1.45 (1.6) | 1.49 (1.8) | 0.92 (0.3) | 2.79 (7.4) | 7.10 (50.0) |
| Medium weed pressure | 3.30 (10.4) | 6.35 (39.8) | 3.64 (12.9) | 1.92 (3.2) | 1.70 (2.4) | 1.81 (2.8) | 2.84 (7.6) | 8.99 (80.9) |
| High weed pressure | 4.67 (21.5) | 10.95 (119.6) | 5.18 (26.6) | 4.20 (17.2) | 2.99 (8.5) | 2.31 (5.0) | 2.84 (7.6) | 14.37 (206.1) |
| LSD (p=0.05) | 0.36 | 0.47 | 0.29 | 0.35 | 0.38 | 0.38 | NS | 0.43 |
| *Cultivars* | | | | | | | | |
| Arize 6129 | 3.62 (12.6) | 7.37 (53.8) | 4.06 (16.0) | 2.50 (5.7) | 2.16 (4.2) | 1.77 (1.6) | 2.84 (7.6) | 10.25 (103.7) |
| Arize 6444 | 3.21 (9.8) | 6.98 (48.2) | 3.98 (15.3) | 2.66 (6.6) | 2.12 (4.0) | 1.59 (2.0) | 2.79 (7.3) | 9.80 (95.2) |
| Arize Dhani | 3.24 (10.0) | 7.53 (56.2) | 4.02 (15.7) | 2.30 (4.8) | 1.92 (3.2) | 1.62 (2.2) | 2.76 (7.2) | 10.08 (101.2) |
| Swarna Shreya | 3.61 (12.5) | 7.65 (58.0) | 3.73 (13.4) | 2.32 (4.9) | 1.85 (2.9) | 1.70 (2.4) | 2.89 (7.9) | 10.26 (104.4) |
| Rajendra Sweta | 3.82 (14.1) | 7.14 (50.5) | 4.04 (15.8) | 2.74 (7.0) | 2.01 (3.5) | 1.54 (1.9) | 2.80 (7.4) | 10.13 (102.1) |
| MTU 7029 | 3.72 (13.3) | 7.56 (56.6) | 3.80 (13.9) | 2.60 (6.3) | 2.30 (4.8) | 1.88 (3.1) | 2.86 (7.7) | 10.40 (107.5) |
| LSD (p=0.05) | 0.45 | 0.40 | NS | NS | NS | 0.26 | NS | 0.40 |

Low weed pressure: pre-emergence application (PE) of pretilachlor 2 DAT *fb* post-emergence application (PoE) of bispyribac-sodium at 20 DAT *fb* 1 HW at 35 days after transplanting (DAT); Medium weed pressure: pretilachlor PE at 2 DAT *fb* bispyribac- sodium PoE at 20 DAT; High weed pressure: weedy check

**Table 2. Weed biomass (g/m$^2$) at 60 DAT as influenced by rice cultivars and weed management practices (pooled data of 2 years)**

| Treatment | *Brachariaria ramosa* | *Trianthema portulacastrum* | *Cyperus rotundus* | *Echinochloa colona* | *Caesulia axillaris* | *Physalis minima* | Other weeds | Total biomass |
|---|---|---|---|---|---|---|---|---|
| *Weed management practices* | | | | | | | | |
| Low weed pressure | 1.68 (2.32) | 2.56 (6.05) | 1.76 (2.59) | 1.38 (1.40) | 1.15 (0.82) | 0.80 (0.14) | 1.93 (3.22) | 4.23 (17.39) |
| Medium weed pressure | 1.93 (3.22) | 3.31 (10.46) | 1.98 (3.42) | 1.59 (2.03) | 1.30 (1.22) | 1.26 (1.09) | 1.89 (3.09) | 5.07 (25.20) |
| High weed pressure | 2.44 (5.45) | 4.63 (20.94) | 2.54 (5.95) | 3.54 (12.03) | 2.29 (4.74) | 1.49 (1.72) | 2.13 (4.04) | 7.50 (55.75) |
| LSD (p=0.05) | 0.15 | 0.20 | 0.11 | 0.33 | 0.27 | 0.24 | 0.30 | 0.24 |
| *Cultivars* | | | | | | | | |
| Arize 6129 | 1.90 (3.11) | 3.62 (12.60) | 2.18 (4.44) | 2.17 (4.21) | 1.71 (2.42) | 1.31 (1.22) | 2.02 (3.58) | 5.73 (32.33) |
| Arize 6444 | 1.78 (2.67) | 3.47 (11.54) | 2.08 (3.98) | 2.24 (4.52) | 1.65 (2.22) | 1.20 (0.94) | 1.91 (3.15) | 5.49 (29.64) |
| Arize Dhani | 1.73 (2.50) | 3.55 (12.10) | 2.15 (4.12) | 1.84 (2.89) | 1.55 (1.90) | 1.02 (0.54) | 1.93 (3.22) | 5.35 (28.12) |
| Swarna Shreya | 1.99 (3.46) | 3.40 (11.60) | 2.13 (4.04) | 2.03 (3.62) | 1.41 (1.59) | 1.15 (0.82) | 1.89 (3.10) | 5.40 (28.66) |
| Rajendra Sweta | 2.34 (4.98) | 3.42 (11.20) | 2.11 (3.99) | 2.39 (5.21) | 1.47 (1.66) | 1.09 (0.69) | 1.92 (3.19) | 5.72 (32.22) |
| MTU 7029 | 2.35 (5.02) | 3.53 (11.96) | 1.92 (3.19) | 2.35 (5.02) | 1.70 (2.39) | 1.33 (1.27) | 2.23 (4.47) | 5.91 (34.43) |
| LSD (p=0.05) | 0.28 | NS | NS | NS | 0.19 | 0.18 | NS | 0.26 |

Low weed pressure: pre-emergence application (PE) of pretilachlor 2 DAT *fb* post-emergence application (PoE) of bispyribac-sodium at 20 DAT *fb* 1 HW at 35 days after transplanting (DAT); Medium weed pressure: pretilachlor PE at 2 DAT *fb* bispyribac- sodium PoE at 20 DAT; High weed pressure: weedy check cm). Number of filled grains/panicle were significantly lower in MTU 7029 (123.1) compared to other varieties (164.5-169.7) and hybrids (156.7-163.9). Early duration rice produced higher grain yields due to early completion of maturity without facing post-flowering drought during October month.

Interaction effect between weed management and rice cultivars for grain yield was significant. Grain yield decreased with increasing levels of weed pressure. However, the rate of reduction due to high weed pressure was maximum with long-duration rice variety MTU 7029 (46.63%) compared to other varieties (35%) and hybrids (20.93-27.42%) (**Table 4**). This might be due to less weed suppression due to shorter height of the variety, and longer duration of maturity (153 days) resulting in higher weed biomass and setback of post-flowering drought stress (Kumar *et al*. 2016). Hybrids produced higher grain yield compared to varieties even under high weed pressure. In the present study, higher net returns and B:C were obtained with rice hybrids compared to varieties. Arize 6129 (among hybrids) and Swarna Shreya (among varieties) had significantly higher net returns of ₹ 83,895 and ₹ 55,201/ha due to better crop productivity. In spite of higher cost of cultivation, net returns (₹ 66,763/ha) and B:C (2.22) were significantly higher with low weed pressure compared to medium and high weed pressures due to higher grain yield (**Table 5**).

It may be concluded that hybrids have better weed competitive ability than the varieties. Growing of high yielding rice hybrids Arize 6129, Arize 6444 or Arize Dhani and cultivar Swarna Shreya with adequate weed management by using pretilachlor

**Table 3. Growth attributes and crop phenology as influenced by rice cultivars and weed management treatments (pooled data of 2 years)**

| Treatment | Plant height (cm) | Leaf area index | Dry matter/ hill (g) | Tillers / $m^2$ (no.) | Days to 50% flowering | Days to maturity (no.) | Panicle length (cm) | Grains/ panicle (no.) | Filled grains/ panicle (no.) | Chaffy grains/ panicle (no.) | 1000-grain weight (g) | Grain yield (t/ha) 2018 | Grain yield (t/ha) 2019 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Weed management practices* | | | | | | | | | | | | | |
| Low weed pressure | 103.3 | 11.08 | 97.9 | 238.4 | 96.1 | 137 | 24.9 | 215.2 | 189.4 | 25.8 | 23.2 | 5.11 | 6.11 |
| Medium weed pressure | 101.3 | 8.26 | 88.8 | 191.1 | 91.1 | 134 | 23.8 | 198.8 | 161.1 | 37.7 | 21.7 | 4.44 | 5.38 |
| High weed pressure | 103.6 | 2.79 | 90.2 | 124.5 | 89.2 | 132 | 22.1 | 170.8 | 117.8 | 53.0 | 20.5 | 3.04 | 4.66 |
| LSD (p=0.05) | 1.7 | 0.91 | 1.7 | 15.7 | 1.7 | 2.0 | 0.9 | 18.1 | 18.4 | 7.1 | 0.7 | 0.16 | 0.34 |
| *Cultivars* | | | | | | | | | | | | | |
| Arize 6129 (SD) | 106.1 | 7.17 | 109.4 | 199.1 | 79.1 | 112 | 24.8 | 183.3 | 158.8 | 24.4 | 23.9 | 5.25 | 6.10 |
| Arize 6444 (MD) | 107.4 | 8.71 | 110.1 | 187.8 | 83.2 | 122 | 24.9 | 203.7 | 163.9 | 39.9 | 24.5 | 4.74 | 5.73 |
| Arize Dhani (LD) | 101.9 | 8.57 | 104.5 | 163.9 | 93.1 | 137 | 24.3 | 198.3 | 156.7 | 41.6 | 22.0 | 4.64 | 5.56 |
| Swarna Shreya (SD) | 103.6 | 5.39 | 106.2 | 169.8 | 78.4 | 136 | 24.6 | 203.7 | 164.5 | 39.3 | 22.8 | 3.82 | 5.25 |
| Rajendra Sweta (MD) | 103.1 | 6.79 | 105.8 | 197.7 | 88.1 | 145 | 20.6 | 213.2 | 169.7 | 43.6 | 14.2 | 3.35 | 4.98 |
| MTU 7029 (LD) | 94.6 | 7.62 | 18.0 | 189.8 | 119.6 | 153 | 22.5 | 167.3 | 123.1 | 44.3 | 23.6 | 3.39 | 4.68 |
| LSD (p=0.05) | 2.8 | 1.76 | 2.5 | 20.0 | 2.5 | 3 | 1.7 | 27.6 | 23.1 | 13.0 | 0.9 | 0.23 | 0.28 |

Low weed pressure: pre-emergence application (PE) of pretilachlor 2 DAT *fb* post-emergence application (PoE) of bispyribac-sodium at 20 DAT *fb* 1 HW at 35 days after transplanting (DAT); Medium weed pressure: pretilachlor PE at 2 DAT *fb* bispyribac- sodium PoE at 20 DAT; High weed pressure: weedy check

**Table 4. Interaction effect of grain yield as influenced by rice cultivars and weed management treatments in transplanted rice (pooled data of 2 years)**

| Cultivars (V) | Weed management treatments (W): Low weed pressure | Medium weed pressure | High weed pressure | Mean | Reduction in yield due to high weed pressure compared to low weed pressure (%) |
|---|---|---|---|---|---|
| Arize 6129 | 6.57 | 5.62 | 4.85 | 5.68 | 26.18 |
| Arize 6444 | 5.83 | 5.27 | 4.61 | 5.23 | 20.93 |
| Arize Dhani | 5.98 | 4.99 | 4.34 | 5.10 | 27.42 |
| Swarna Shreya | 5.40 | 4.73 | 3.49 | 4.54 | 35.37 |
| Rajendra Sweta | 4.86 | 4.50 | 3.14 | 4.16 | 35.40 |
| MTU 7029 | 5.04 | 4.39 | 2.69 | 4.04 | 46.63 |
| Mean | 5.61 | 4.91 | 3.85 | | |
| LSD ($p$=0.05) | V | W | V×W | | |
| | 0.26 | 0.25 | 0.62 | | |

Low weed pressure: pre-emergence application (PE) of pretilachlor 2 DAT *fb* post-emergence application (PoE) of bispyribac-sodium at 20 DAT *fb* 1 HW at 35 days after transplanting (DAT); Medium weed pressure: pretilachlor PE at 2 DAT *fb* bispyribac- sodium PoE at 20 DAT; High weed pressure: weedy check

**Table 5. Economics as influenced by rice cultivars and weed management treatments (pooled data of 2 years)**

| Treatment | Cost of cultivation (x10³ ₹/ha) | Gross returns (x10³ ₹/ha) | Net returns (x10³ ₹/ha) | B:C |
|---|---|---|---|---|
| *Weed management practices* | | | | |
| Low weed pressure | 54.60 | 121.37 | 66.76 | 2.22 |
| Medium weed pressure | 52.26 | 111.84 | 59.58 | 2.14 |
| High weed pressure | 50.24 | 101.38 | 51.14 | 2.02 |
| LSD (p=0.05) | | 3.91 | 3.91 | 0.08 |
| *Cultivars* | | | | |
| Arize 6129 | 52.54 | 136.14 | 83.59 | 2.59 |
| Arize 6444 | 53.19 | 118.75 | 65.56 | 2.24 |
| Arize Dhani | 51.94 | 119.25 | 67.30 | 2.30 |
| Swarna Shreya | 52.59 | 107.79 | 55.20 | 2.05 |
| Rajendra Sweta | 51.65 | 101.89 | 50.24 | 1.97 |
| MTU 7029 | 52.30 | 75.37 | 23.07 | 1.42 |
| LSD (p=0.05) | | 5.11 | 5.11 | 0.10 |

Low weed pressure: pre-emergence application (PE) of pretilachlor 2 DAT *fb* post-emergence application (PoE) of bispyribac-sodium at 20 DAT *fb* 1 HW at 35 days after transplanting (DAT); Medium weed pressure: pretilachlor PE at 2 DAT *fb* bispyribac- sodium PoE at 20 DAT; High weed pressure: weedy check

0.60 kg/ha PE fb bispyribac-sodium PoE 30 g/ha at 20 DAT *fb* one manual weeding at 25 DAT is a better option to manage the weeds and improve the transplanted rice productivity and profitability under rainfed ecosystem of middle Indo-Gangetic plains.

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