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Effect of Depth of Sowing and Mulching on Rainfed Chickpea (*Cicer arietinum*) in Red and Lateritic Belt of West Bengal

Krishna Das, Binoy Kumar Saren, Kalipada Pramanik

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ABSTRACT

Background: Availability of soil moisture is a serious bottleneck for successful growing of post monsoon crops in red and lateritic soil. Hence, soil moisture conservation is crucial for post monsoon crops. In this aspect using mulches for conservation of moisture and optimum depth of sowing for proper germination and seedling emergence are important crop management practices in red and lateritic soil.

Methods: The experiment was laid out in split plot design with three depths of sowing as main-plot treatments and four mulching practices as subplot treatments replicated thrice. Measured growth parameters were plant height (cm), number of branches plant^{-1}, dry matter accumulation (g m^{-2}) and leaf area index (LAI); yield attributes such as effective branches m^{-2}, number of mature pods branch^{-1}, number of seeds pod^{-1} and seed index; grain and stalk yield. Economics of cultivation was assessed in terms of cost of cultivation, gross and net return and net return per invested.

Result: Chickpea sown planted at 7.5 cm depth of sowing recorded maximum yield, consumptive water use efficiency and profitability. Application of 7.5 t ha^{-1} straw mulch registered significantly higher yield of chickpea, consumptive water use efficiency and profitability.

Key words: Chickpea, Consumptive water use efficiency, Depth of sowing, Mulching, Profitability, Yield.

INTRODUCTION

India has about 108 million hectares of rainfed area out of total 143 million hectares of cultivated land which constitutes about 75 per cent of agricultural land (Reddy, 2013). Pulses are very important world food crops providing more plant protein than cereals as well as used as feed to the vast cattle population in the form of hay, green fodder, concentrate and number of bi-products besides as green manure crops. In the world, India is the largest producer and consumer of pulse accounting for about 25% of global production, 27% of consumption and 14% of the world import (Shukla and Mishra, 2018). The demand for pulses in India will increase with a growing population as well as sustained economic growth (Raja *et al*., 2017). Chickpea (*Cicer arietinum* L.) is an important pulse crop cultivated in India during *rabi* season. Among pulses, chickpea is a preferred food legume in some regions because of its multiple uses Siddique *et al*., 2000. Chickpeas are a nutrient-dense food and 100 g chickpea supplies approximately 368 kcal energy, 21 g protein, 5.7 g fat, 61 g carbohydrates and 22.7% total dietary fiber.

Chickpea is a post monsoon crop; it is grown mainly on residual soil moisture. Hence, appropriate technology like optimizing the depth of sowing and measures to reduce loss of soil moisture are required for successful cultivation and higher production of chickpea in rainfed areas.

Soil water potential or availability of soil moisture and depth of seeding controls the rate of germination and emergence. When the soil moisture content is not adequate, the rate of germination is delayed and the stands will be thin with weakened plants. On the other hand, seeding depth also considerably influences seed germination, emergence and plant stand. The effect of seeding depth is more important in rainfed areas where crops are primarily raised on conserved soil moisture. Deeper seeding may cause poor emergence and shallow depth may lead to poor germination on account of low soil moisture in the surface layer. Therefore, proper depth of seeding produces optimum plant population. To get desired plant population of a crop, supply of optimum moisture is essential. In rainfed areas, there is less provision for supplemental irrigation. Therefore, moisture conservation is the top priority for successful cultivation of crops. In this regards, reduction of moisture loss or conservation of soil moisture using mulches is one of the best options. Among various types of mulching materials straw is the best. Straw mulching not only modifies the micro climate but also influences the rhizosphere and productivity. Mulching improves soil hydrothermal conditions and reduces the evaporation of soil water (Wang *et al*., 2005). Straw mulching enhances soil water storage and soil moisture conservation (Zhang *et al*., 2005), regulates the

Department of Agronomy, Palli Siksha Bhavana, Visva-Bharati, Sriniketan-731 204, West Bengal, India.

Corresponding Author: Kalipada Pramanik, Department of Agronomy, Palli Siksha Bhavana, Visva-Bharati, Sriniketan-731 204, West Bengal, India. Email: kalipada.pramanik@visva-bharati.ac.in

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soil temperature and stimulates soil biological activity (Li *et al*., 2018). It also improves crop yield and water use efficiency (Zhao *et al*., 2014). Zhao *et al*. (2009) showed that the soil moisture content under straw mulching was 17.7-75.9% higher than that of under the non-mulching treatment and the yield of wheat increased by 3.2-8% compared with that of the non-mulching treatment. Specifically, the area where more than 80% of annual rainfall is received during monsoon period and rest of the month receives very scanty amount of rainfall results in insufficient soil moisture for proper plant growth. Further, lack of irrigation facilities makes the problem more complex. Keeping all the above facts in view, the present investigation was undertaken to evaluate the effect of depth of sowing and mulching on the performance of rainfed chickpea.

MATERIALS AND METHODS

The field experiment on chickpea was carried out during the *rabi* season (December to March) of the year 2019-20 at the Research Farm of Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati, Sriniketan, Birbhum, West Bengal which is located in sub-humid semi-arid climate under red and lateritic belt. The soil of the experimental field was sandy loam in texture having good drainage and moderate water holding capacity. The soil was acidic in reaction (pH 5.17), low in salt content (0.30 dSm^{-1}), low in organic carbon (0.47 %), low in available nitrogen (205.82 kg N ha^{-1}), medium in available phosphorus (42.53 kg P_2O_5 ha^{-1}) and medium in available potassium (131.42 kg K_2O ha^{-1}).

The crop received total rainfall of 83.7 mm during the cropping period of 2019-20. The meteorological data of the experimental site that prevailed from December 2019 to March 2020 with respect to rainfall, relative humidity and temperature obtained from the agro-meteorological advisory services (Sriniketan Meteorological Station, Government of India) is presented in Fig 1.

The field experiment was carried out in split plot design, consisting of three depths of sowing in main plots *i.e.*, 5 cm depth of sowing, 7.5 cm depth of sowing and 10 cm depth of sowing and four levels of mulching in sub-plots *i.e.*, No mulching, 2.5 t ha^{-1} dry straw mulching on seeded row, 5.0 t ha^{-1} dry straw mulching within row and 7.5 t ha^{-1} dry straw mulching within row and replicated thrice. There were thirty-six plots in total, each measuring 3 m × 4 m. Recommended dose of fertilizer @ 20:50:40 (N: P_2O_5:K_2O) kg ha^{-1} was applied basal in each plot just before sowing and were subsequently mixed thoroughly with the soil. The seeds of the variety JAKI-9218 were sown on 7th December, 2019 at a rate of 80 kg ha^{-1} with a row spacing of 30 cm and intra-row spacing of 10 cm. Straw mulch was weighed and applied as per the treatment immediately after sowing. Plant protection measures were taken against insects, weeds and diseases. The crop was harvested on 16th March, 2020. Observations on growth attributes such as plant height (cm), number of branches $plant^{-1}$, dry matter accumulation (g m^{-2}), leaf area index (LAI) of chickpea were recorded. Yield attributes such as effective branches m^{-2}, number of mature pods $branch^{-1}$, number of seeds pod^{-1}, seed index were recorded. Observations on grain and stalk yield were recorded per individual plots and converted into kg ha^{-1}. Soil samples were collected from 0-15 cm,15-30 cm layers with the help of screw auger just after sowing, at different stages of crop growth, at harvesting and total consumptive use (cm) was computed by using water depletion method from the moisture percentage data and bulk density (gcc^{-1}) of the soil at respective depth in each plot. Consumptive use of water by the crop has been calculated by the following formula:

$$U = \sum_{i=1}^{n} \left\{ \frac{M_{1i} - M_{2i}}{100} \times BDi \times Di + ER\ (cm) \right\}$$

$$CU = \sum_{i=1}^{n} U$$

Where,

U = Consumptive use (cm) during a given period.

CU = Total seasonal consumptive use (cm).

M_{1i} = Soil moisture percentage of initial soil samples or just after rainfall in i^{th} layer of the soil.

M_{2i} = Soil moisture percentage of next soil samples or at harvest in i^{th} layer of the soil.

BD_i = Bulk density of the i^{th} soil layer (gcc^{-1}).

D_i = Depth of i^{th} soil layer.

n = Number of soil layers in the root zone (0-15, 15-30).

ER = Effective rainfall during crop growth period (cm) For estimation of ER the following formula were used as given by Water Service of FAO.

$$P_{eff} = 0.6 \times P\text{-}10 \text{ for } P_{month} < 70 \text{ mm}$$

$$P_{eff} = 0.8 \times P\text{-}24 \text{ for } P_{month} > 70 \text{ mm}$$

Where,

P_{month} = Monthly rainfall, mm.

P_{eff} = Effective rainfall, mm

Consumptive use efficiency has been determined by using the following expression,

$$CUE = \frac{Yield}{CU}\ (kg\ ha^{-1}cm^{-1})$$

Where,

Y = Seed yield (kg ha^{-1}).

CU = Consumptive use of water (cm) which is expressed in kg ha^{-1} cm^{-1}.

Cost of various inputs like seed, fertilizer, labour, ploughing, herbicide, fungicide *etc*., used in the experiment were calculated as per available market price of these items for calculation of cost of cultivation. Price of chickpea seed was calculated as per available market price to find out gross return (₹ ha^{-1}), net return (₹ ha^{-1}) and returns per rupee invested in different treatments.

The statistical analysis was carried out by the analysis of variance (ANOVA) method (Fisher, 1960; Cochran and Cox, 1960; Panse and Sukhatme, 1978; Gomez and Gomez, 1984). The significance of different source of variations was tested by "Error Mean Square Method" of Fisher Snedecor's 'F' test at probability level of 0.05 for error degree of freedom. Fisher and Yate's table (1953) has been followed for interpreting the effect of different treatments under different cases for testing of critical differences (CD) at 5% level of significant. The standard error of mean [SEm (±)], the value of critical differences (CD) was calculated to compare the differences between treatments means and co-efficient of variation (CV %).

RESULTS AND DISCUSSION

Growth parameters

The data for one year of study are presented in Table 1 to show the impact of depth of sowing and straw mulching on dry matter accumulation (g m^{-2}), leaf area index and number of branches $plant^{-1}$, plant height (cm) at harvest stage of the "JAKI 9218" variety of chickpea. The observations showed that depth of sowing did not show any significant impact in increasing plant height among different depth of sowing. Straw mulching within row at 7.5 t ha^{-1} and 5.0 t ha^{-1} exhibited the tallest plants among different mulching treatments, while straw mulching on seeded row at 2.5 t ha^{-1} and no mulching presented significantly lower plant height than straw mulching within row at 7.5 t ha^{-1}. Straw mulching on seeded row at 2.5 t ha^{-1} showed significantly higher plant height than no mulching (Table 1). The greater plant height with straw mulching might be due to the moisture conservation in mulched plots which probably helped in growth and development of the crop. Similar study was reported by Kumar *et al.* (2020).

The data on the dry matter accumulation (gm^{-2}) revealed that the depth of sowing and straw mulching influenced the

Table 1: Effect of depth of sowing and mulching on growth attributes of rainfed chickpea.

Treatment	Plant height (cm) at harvest	Dry matter accumulation (gm^{-2}) at 90 DAS	Leaf area index at 90 DAS	No. of branches $plant^{-1}$ at harvest
Depth of sowing (cm)				
5.0	39.6	217	1.42	5.4
7.5	41.6	227	1.48	6.1
10.0	41.0	234	1.69	6.4
SEm (±)	1.12	2.9	0.03	0.12
CD at 5%	NS	11.6	0.12	0.46
Mulching with straw				
No mulching	36.2	205	1.24	5.43
2.5 t ha^{-1} on seeded row	40.6	223	1.45	5.88
5.0 t ha^{-1} within row	42.5	231	1.63	6.29
7.5 t ha^{-1} within row	43.6	244	1.79	6.24
SEm (±)	0.74	2.5	0.04	0.12
CD at 5%	2.21	7.3	0.11	0.34

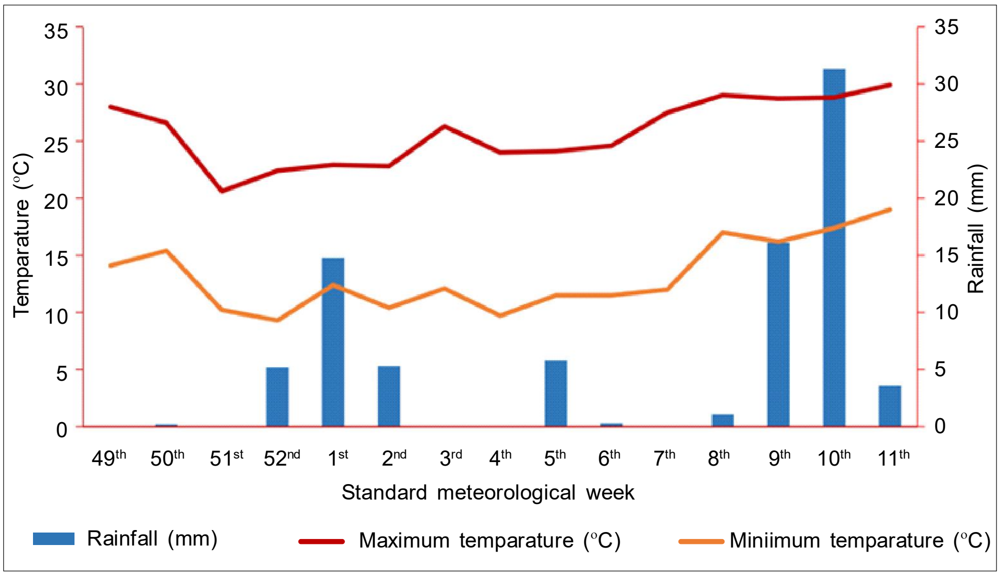

Fig 1: Standard meteorological week data during crop growing period.

dry matter accumulation in "JAKI 9218" variety of chickpea experimentation (Table 1). The treatment 10 cm depth of sowing being statistically on par with 7.5 cm depth of sowing produced a significantly greater dry matter accumulation than the 5 cm depth of sowing. The higher dry matter accumulation might be due to more moisture from monsoon rainfall that was stored in the subsoil below 5 cm and by improving the survival of *Rhizobium* under more favourable soil conditions at this depth. Similar study was also reported by Siddique and Loss (1999). Straw mulching within row at 7.5 t ha^{-1} produced significantly higher dry matter than the straw mulching within row at 5.0 t ha^{-1}, mulching on seeded row at 2.5 t ha^{-1} and control. Even straw mulching within row at 5.0 t ha^{-1} and mulching on seeded row at 2.5 t ha^{-1} recorded significantly greater dry matter accumulation than control *i.e.*, no mulching. The higher dry matter accumulation with straw mulching might be due to creation of favourable soil environment by retaining and providing moisture supply to chickpea crop in *rabi* season.

The result from the experiment revealed that the depth of sowing and straw mulching treatments had significant effect on leaf area index of chickpea. The highest LAI (1.69) was observed in 10 cm depth of sowing and it was significantly higher than 5.0 and 7.5 cm depth of sowing in this experiment. Similar result was reported by Malviya *et al.* (2010). Straw mulching with 7.5 t ha^{-1} produced the highest LAI (1.79) followed by 5 t ha^{-1} straw mulching (1.63) due to higher moisture conserved in mulched plots which improved growth and development of the leaves and the lowest LAI (1.24) was found in control *i.e.*, in no mulching treatment.

The observation on number of branches $plant^{-1}$ revealed that depth of sowing had significant effect on branches $plant^{-1}$ in "JAKI 9218" variety of chickpea. The highest number of branches $plant^{-1}$ (6.4) was recorded under 10 cm depth of sowing; however, it was on par with 7.5 cm depth of sowing (6.1) and the lowest number of branches $plant^{-1}$ (5.4) was obtained from 5 cm depth of sowing. Among different straw mulching treatments, mulching within row at 7.5 t ha^{-1} registered higher values in number of branches $plant^{-1}$ and mulching within row at 5.0 t ha^{-1} closely followed it; however, these two treatments were statistically on par as reflected in observed data.

No mulching resulted in the least values of number of branches $plant^{-1}$at harvest. The better crop growth produces more number branches might be explained as due to more retention as well as supply of soil moisture for a longer period under straw mulching (Dey *et al.*, 2014). The result is also similar to the study of Kumar *et al.* (2020).

Yield attributes

The data on yield attributes of "JAKI 9218" chickpea indicated that depth of sowing the yield parameters like number of effective branches m^{-2} and number of pods effective $branch^{-1}$ (Table 2). The present study revealed that the treatment 10 cm depth of sowing being statistically on par with 7.5 cm depth of sowing registered significantly higher number of effective branches m^{-2} and number of pods effective $branch^{-1}$ than the 5 cm depth of sowing. Sowing greater depth may enhance establishment due to higher soil water content in the seed zone, leading to better growth which results in higher number of effective branches m^{-2} and number of pods effective $branch^{-1}$. The result is corroborated with Mahdi *et al.* (1998). The data showed that depth of sowing did not show any significant impact in increasing number of seeds pod^{-1} and seed index (weight of 100 seeds) among different depth of sowing. Mulching with straw treatments also significantly affected yield parameters like number of effective branches m^{-2}, number of pods effective $branch^{-1}$, number of seeds pod^{-1} and seed index of "JAKI 9218" chickpea (Table 2). The data on number of effective branches m^{-2} and number of pods effective $branch^{-1}$ revealed that the straw mulching within row at 7.5 t ha^{-1} being statistically on par with 5.0 t ha^{-1} registered significantly higher number of effective branches m^{-2} and number of pods effective $branch^{-1}$ than mulching on seeded row at 2.5 t ha^{-1} and no mulching treatment. Among different straw mulching treatments, straw mulching within row at 7.5 t ha^{-1} registered higher values in number of seeds pod^{-1} and seed index of "JAKI 9218" chick pea and 5.0 t ha^{-1} of straw closely followed it; however, these two treatments were statistically on par. But straw mulching within row at 7.5 t ha^{-1} registered the significant superiority over the treatment no mulching. This might be due to higher soil moisture gained by the crop in mulched plot which helped to produce bold and sound seeds. Similar study was reported by Dey *et al.* (2014).

Yield

The result of the treatments on grain and stalk yields of chickpea in the present experiment was narrated in the following segment. Grain and stalk yields of "JAKI 9218" chick pea were not influenced by depth of sowing (Table 3).

Table 2: Effect of depth of sowing and mulching on yield attributes of rainfed chickpea.

Treatment	Effective branches m^{-2}	Pods $branch^{-1}$	Grains pod^{-1}	Seed index (g)
Depth of sowing (cm)				5.0
163	5.1	1.3	21.98	
7.5	189	6.1	1.3	22.86
10.0	188	6.1	1.3	22.65
SEm (±)	2.4	0.10	0.02	0.47
CD at 5%	9.4	0.38	NS	NS
Mulching with straw				
No mulching	163	4.7	1.2	20.98
2.5 t ha^{-1} on seeded row	179	5.4	1.3	22.44
5.0 t ha^{-1} within row	185	6.4	1.3	23.11
7.5 t ha^{-1} within row	193	6.5	1.4	23.44
SEm (±)	3.0	0.14	0.03	0.53
CD at 5%	9.0	0.43	0.10	1.56

Table 3: Effect of depth of sowing and mulching on yield and economics of rainfed chickpea.

Treatment	Grain yield (kg ha^{-1})	Stalk yield (kg ha^{-1})	Cost of cultivation (₹ ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	Return per rupee invested
Depth of sowing (cm)						
5.0	1110	2442	32144	90063	57919	2.80
7.5	1209	2572	32584	98036	65453	3.01
10.0	1175	2495	33024	95252	62229	2.88
SEm (±)	33.6	46.1	-	2712	2712	0.08
CD at 5%	NS	NS	-	NS	NS	NS
Mulching with straw						
No mulching	980	2261	32184	79568	47384	2.47
2.5 t ha^{-1} on seeded row	1138	2474	32744	92268	59524	2.82
5.0 t ha^{-1} within row	1222	2617	31984	99067	67083	3.10
7.5 t ha^{-1} within row	1319	2659	33424	106899	73476	3.20
SEm (±)	20.0	34.2	-	1615	1615	0.05
CD at 5%	59.5	101.5	-	4798	4798	0.15

Table 4: Effect of depth of sowing and mulching on consumptive use and consumptive use efficiency of rainfed chickpea.

Treatment	Consumptive use (cm)	Consumptive use efficiency (kg ha^{-1} cm^{-1})
Depth of sowing		
5.0	22.62	49.78
7.5	23.84	51.18
10.0	26.01	45.44
SEm (±)	-	1.37
CD at 5%	-	NS
Mulching with straw		
No mulching	26.05	37.71
2.5 t ha^{-1} on seeded row	24.70	46.04
5.0 t ha^{-1} within row	23.31	52.53
7.5 t ha^{-1} within row	22.56	58.92
SEm (±)	-	0.81
CD at 5%	-	2.42

Among the depth of sowing treatments, 7.5 cm depth of sowing recorded higher grain and stalk yields over 10.0 and 5.0 cm depth of sowing but they were on par. Among the straw mulching treatments, 7.5 t ha^{-1} straw mulching within row registered a significantly higher grain yield than other treatments, such as 5.0 t ha^{-1} straw mulching within row, 2.5 t ha^{-1} straw mulching on seeded row and no mulching, as noted in this experiment. The data showed that yield enhancement in 7.5 t ha^{-1} and 5.0 t ha^{-1} straw mulching within row was 35% and 25% over no mulching. 2.5 t ha^{-1} on seeded row recorded a significantly lower yield than 7.5 t ha^{-1} and 5.0 t ha^{-1} straw mulching within row.

Among straw mulching treatments,7.5 t ha^{-1} straw mulching within row resulted in the maximum stalk yield but being statistically on par with 5.0 t ha^{-1} straw mulching within row produced significantly higher straw yield than 2.5 t ha^{-1} on seeded row and no mulching. The percentage increase in stalk yield of 7.5 t ha^{-1} straw mulching within row, 5.0 t ha^{-1} straw mulching within row and 2.5 t ha^{-1} straw mulching on seeded row over no mulching was 17.6, 15.7 and 9.4%, respectively. The highest grain yield (1319 kg ha^{-1}) and stalk yield (2659 kg ha^{-1}) were observed in 7.5 t ha^{-1} straw mulching due to higher plant population at the harvest time, more test weight, higher number of seeds pod^{-1} and higher dry matter accumulation in the mulched plot. Similar study was reported by Dey *et al*. (2014).

Consumptive use of water

Consumptive use of water by the chickpea crop was calculated considering soil moisture contribution and effective rainfall only. The ground water level at the experimental site was much below the effective root zone of the crop. Hence, the ground water table contribution for growing the crop was not considered in the present investigation. The results presented in Table 4 revealed that the water used consumptively by the crop was maximum (26.01 cm) at 10 cm depth sown crop and was minimum (22.62 cm) at 5 cm depth of sown plot. Similar study was reported by Fetri *et al*. (2016). The crop grown without mulching (control plot) showed maximum (26.05 cm) consumptive use probably due to the highest loss of soil moisture through evaporation and transpiration from the field. Consumptive water use was found lowest (22.56 cm) under mulching with 7.5 t ha^{-1}. Similar result was reported by Abd El-Mageed *et al*. (2018).

Depth of sowing exerted non-significant effect on consumptive use efficiency of chickpea. The crop at 7.5 cm depth sown plot produced highest (51.18 kg ha^{-1} cm^{-1}) consumptive use efficiency and the crop sown at 10 cm depth produced the lowest (45.44 kg ha^{-1} cm^{-1}) consumptive use efficiency (Table 4). Similar study was reported by Fetri *et al*. (2016). In case of mulching, the highest consumptive use efficiency (58.92 kg ha^{-1} cm^{-1}) was recorded by 7.5 t ha^{-1} straw mulching and it was significantly higher than that of control (37.71 kg ha^{-1} cm^{-1}). This might be caused by higher crop yield and lower soil moisture loss resulting lower consumptive use in the mulched plot than the control one.

CONCLUSION

Experiment results revealed that chickpea responded to depth of sowing and mulching with improvement in growth and productivity. Therefore, maintaining 7.5 cm depth of sowing and application of straw mulch at the rate of 7.5 t ha^{-1} could be recommended for maximum yield, higher consumptive use efficiency and higher net return in red and lateritic sandy loam soils.

Conflict of interest: None.

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