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Effect of land topography, soil fertility levels and pre-pruning rest period of *palas* (*Butea monosperma* Lam.) on lac production

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Abstract

An experiment was conducted in the research farm of ICAR-National Institute of Secondary Agriculture, Ranchi during 2019-24 to evaluate the effects of land topography, soil fertility levels and pre-pruning rest periods on growth and lac production on *palas* trees. Two levels of topography (upland and lowland), four levels of soil fertility [i) control. ii) lime 2 kg/ tree, iii) recommended dose i.e. 2 kg lime+ NPK @ 200, 150 and 500 g +25 kg FYM/ tree and iv) double the recommended dose] and two levels of rest i.e. 7 and 19 months were combined together to make 16 treatment combinations replicated four times and allocated following Randomized Complete Block Design (RCBD) in factorial mode. Growth of *palas* tree was affected significantly by topography and rest periods. Upland condition recorded 39 percent increase in residual bio-mass compared lowland condition. However, residual bio-mass fell significantly (46 percent) due to adoption of long duration of rest period compared to shorter rest. In case of lac yield ratio, values were 4.21 and 2.81 in upland and lowland respectively. Favourable microclimate in uplands is the reason behind this increase in yield. In contrary to growth parameters, lac yield ratio was found to increase 112.4 percent in longer rest period compared to shorter rest period.

Key words: *Butea*, topography, soil fertility, rest, *Kerria*

Statements and Declarations

Competing Interests:

It is declared that there is no clash of interest regarding ownership partially of fully in this paper

Palas (*Butea monosperma* Lam.) trees are known for its multifarious uses. It belongs to family Fabaceae and sub-family Papilionaceae. Various plant parts of the tree are used for curing many ailments in Ayurveda and other alternative medicines (Tiwari et al. 2019; Kumari et al. 2022). Due to its wide adaptability, it is available in wide range of ecosystems (Singh et al. 2016). Leaves of this tree are used for making "dona" for delivering food/ snacks in local shops. Researchers have reported that the species is efficient in reclamation of degraded lands (Raj et al. 2016). Tree exudate (*gond*) from the tree is widely used in making *laddu* (sweet). Dry wood of this species is used to perform many Hindu rituals, particularly for astrological corrections (Maneesha et al. 2021). Aforesaid usages are important, but these cannot impart large scale impact on farmers' family life. However, best use of the tree can be done if it is used as a host for lac cultivation (Krishnaswami and Singh 1962). Lac is a natural resin of insect origin. Encrustation of lac insect, mainly secreted for protection of its own, grows on soft and tender branches of this host plant. In fact, these encrustations are product of commerce and sold in local markets at high price in lac producing areas. After processing of the same, these are used for making many industrial products like varnish, bangles, perfumery base material, high grade ink, optical cement, gasket shellac, lac dye, lac wax etc. and many more (Ramani et al. 2007). All these aforementioned are high value products. Therefore, sale price of lac is always high among the majority of agricultural produces.

Lac insect has got two strains *i.e. kusmi* and *rangeeni*. Former is somewhat superior so far as commercial traits are concerned and grows mainly on *kusum* trees. While the later grows widely on *palas* trees distributed abundantly in Jharkhand, Chhattisgarh, Odissa, West Bengal, MP, Maharashtra etc states. Ramanan et al.. (2024) reported from Bundelkhand that the species is distributed very well in different agro-ecosystems at a frequency of 10-15 trees per hectare. Moreover it is distributed in the dryer parts and at mixed plantations of the country (Raj et al. 2014). There are two cropping cycles for *rangeeni* lac crop—(i) summer crop of eight months (Nov to July) and (ii) rainy season crop of four months (July to Nov). Lac production in the former cycle is a

challenging one since it meets frequent crop failure. So far, many reasons have been cited behind the failure—environmental factor (climate change), nutritional factors, predator/ parasite factor etc. However, no definite reason has been assigned behind the failure. Agronomical growth factors can ensure proper growth and development of the host, which in turn can ensure proper growth and development of lac insect. Earlier work from this Institute reported a significant role of plant nutrients (Ghosal 2012) and canopy structure of hosts (Ghosal and Mishra 2009) governing lac yield significantly. Therefore, few other agronomical factors like land topography, soil fertility levels and pre-pruning rest period were thought off to examine their role in improving lac yield. An increase in lac yield in summer crop by one or more factors will not only prove to be a technological boon, but also will give an important clue behind lac crop mortality in unfavourable years.

Topography could be one such contributing factors. Literature also suggested that *palas* tree is draught tolerant and light responsive species (Fayiah et al. 2018). Tiwari et al. (2026) discussed while working on *palas* that change in place can bring a large change in soil stress factors, nutrient status and microclimatic variations. In general, upland condition is supposed to be less humid compared to lowland. At the same time, submergence is very much common in lowlands. Both the conditions are supposed to affect plant growth in reverse direction. Further, favourable micro-climate in upland conditions might be more favourable for lac growth since lac insect prefers ventilation and sunshine (Ghosal 2012; Ghosal and Mishra 2009). With this background we can expect that growth and lac yield performance of the tree could be favourable in uplands. Further, in this regard Melandri et al. (2021) described that performance of any species in upland or lowland is very much a species/ variety dependant character.

Growth and health of host plant is essential not only for its sustenance, but also for survival of the insect pests depending on it (Uchida 2000). Bi et al. (2001) opined that nutrient management largely determine insect growth and its population over it. Degree of resistance to insect attack by any plant species is very much dependent on degree of lignification, sugar and protein content of phloem, presence of defensive compounds *etc*. which in turn are very much correlated to nutrient supplying capacity of the soil (Marschner 1995) Phloem sap consists of macro proteins, RNA and micro sugar, hormones, minerals and amino acid (Kehr 2006). All these components help lac to thrive well. Particularly, lime and potassium application in acid lateritic soils can increase lac production significantly (Venugopal, 1929; Ghosal 2012). Besides, soil requires to be strengthened through application of Farm Yard manure (FYM) and some judicious amount of nitrogen and phosphorus to cater basic need of plants keeping in mind poor fertility status of lateritic soils (Ghosal et al. 2016). While working on mealy bug, Fennah (1959) reported that these nutrients influence insect growth significantly. Huber and Thompson (2007) reported that nutrient deficient plants are susceptible to insect –pest attack.

One more factor, which is very important but very less talked about is pre-pruning rest period. *Palas* is a perennial shrub and recommended pruning interval of the host for lac cultivation is two years *i.e.* with actual rest period of seven months (Jaiswal et al. 2000). During the rest period the plant shoots attain good texture and size to sustain adequate growth of lac insect. Recommended pruning interval is too high for *palas* because, due to lac cultivation huge amount of cell sap is drained out of the plant system. The same may vary for other species (Partey 2011) when lac inoculation is not done. Some researchers have reported better lac production when rest period is further increased (Ghosal 2017).

Therefore, to draw a clear cut picture as to how all these factors *i.e*. topography, fertility levels and rest period contribute to lac production, an experiment was conducted during 2019 to 2024 in the Institute Research Farm of ICAR-National Institute of Secondary Agriculture, Ranchi.

Materials and method

The experiment was conducted with two levels of topography, four levels of soil fertility and two levels of pre-pruning rest periods. In the research farm of ICAR-NISA, Ranchi several plots of *palas* are there. Out of these, one located in the highest elevation and also one located in lowest elevation (just beside the low lying pond) were taken up for the study. Now onwards these will be termed as upland and lowland conditions, respectively. As per soil moisture dynamics studied, upland soil was demarcated from lowland with 05 percent lesser average moisture content during October to December. Further, the lowland plots remained submerged in rain water during July to September months on regular basis.

The second factor *i.e*. soil fertility levels consisted of four levels—(i) control (ii) only lime application (2 kg/ tree), (iii) Recommended dose *i.e.* N, P_2O_5 and K_2O application @ 200, 150 and 500 g + 2 kg lime + 25 kg well rotten Farm Yard manure (FYM) per tree and (iv) double the recommended dose.

Before application of manure/ fertilizer/ amendment a 4" deep ring was dug at 60 percent canopy diameter of each tree. Soil fertility treatments were applied every year during monsoon season. Lime was applied at the receipt of first rain shower and rest were applied when rainfall started at full swing. Care was taken in lowland condition so that applied fertilizers ware not washed out, by deepening the ring where required. For supplying lime, agriculture lime available in local market was used. For nitrogen, phosphorus and potassium urea, Diamonium phosphate (DAP) and Muriate of potash (MOP) were used.

To impose rest period as a treatment, trees (with suitable numbering) were divided into two groups *i.e.* (i) with seven months rest and (ii) with 19 months rest. In each case pruning time was April month. While undergoing pruning, care was taken so that thick branches were not cut down and at the same time branches located in top one third of tree were not pruned. From practical experience, this practice of leaving such branches untouched was followed thoroughly to render trees with very less amount of stress.

Other practices

Lac inoculation was done in different groups of trees in the month of July. Good quality broodlac were inoculated as per recommendation (15 g./ m inoculable shoot). Amount of broodlac inoculated per tree was noted down for calculating broodlac output per unit input inoculation in respective parameters.

For control of lac insect predator/ parasites (enemy insect of lac) and fungal diseases, pesticides like ethofenprox/ Indoxacarb/ carbendazim etc. were sprayed in recommended dose and as per spray schedule.

For maintaining general cleanliness of the field, weeding was done from time to time adopting mechanical method (tractor tilling) or by spade tilling (within the dug tree rings). It is further to state that age of the plantation was around 75 years and its geometric distribution was spaced at 3.6 x 3.6 m.

Design of experiment and calculation

All the three factors were combined together to form a set of combinations so that effect of each factor and their interactions could be separated from each other. Details is given below.

Factors

(i) Topography- 02 (upland and lowland)

(ii) Soil fertility—04 [Control, only lime application (2 kg/ tree), recommended dose (lime 2 kg + N 200 g + P_2O5 150 g+ K_2O 500 g + FYM 25 kg) per tree and double the recommended dose]

(iii) Rest period—02 (seven months and nineteen months)

Replications-04

Design- Randomized Block Design in factorial mode

Treatment combinations-16

Calculation was done by estimating ANOVA with the help of Excel sheet following procedure as described by Panse and Sukhatme (1967)

Rational of parameters

Residual bio-mass weight denotes to left over portion of lac bearing shoots after collecting lac settled portions (broodlac). It includes the leaf portion also. Broodlac and sticklac per 10 cm length were estimated with the help of weighing balance and scale while lac yield ratio was estimated by dividing lac production and lac inoculation figures per tree. Encrustation thickness is the measure of growth of lac insect and was estimated with the help of vernier caliper, taking three samples of lac encrustations from each tree. Per cent shoots with lac in a treatment indicate proportion of shoots with satisfactory settlement and growth of lac insect. All these observations were recorded during harvest time. Dry matter percent, a measure of shoot succulence was estimated in February is closely associated to lac insect growth.

Sample collection

Shoot samples from each tree were collected for assessing shoot moisture percent affected by different treatments. However, three soil samples were collected from 30 cm depth from the application area of the tree and mixed together to form a composite sample. Sampling was done in the month of December each year for its analysis of different soil physical and chemical properties (Singh et. al. 1999).

Soil Condition

The soil under experimentation is lateritic soil having acidic soil reaction (pH ~5.2-5.5). Soil texture was clay-loam type.

.

Results and Discussion:

Lac yield ratio:

Effect of topography: Lac yield ratio as influenced by topography, fertility levels and rest period has been depicted in Fig 01. Upland condition could register 49.3 percent higher yield ratio than that of lowland condition. Normally, uplands receive higher intensity of sunshine and UV radiation. At the same time, lowland situated in lower elevation condition invites more dust particles and water vapour. CWV (column water vapour) values are expected to be higher over lowlands as compared to uplands. These observations were reported by Radhakrishnan et al. 2019. Increased water vapour in any atmosphere changes the microclimate of the said area. Thus, a combination of enhanced water vapour and dust particles reduces attenuation of adequate light intensity. Reduced light intensity and poor ventilation leads to poor growth of lac and its yield (Ghosal 2009). This could be the reason behind lower lac yield ratio in lowland condition. Values of sticklac production per unit length of broodlac and encrustation thickness were in conformity to results of lac yield ratio. In other words, it can be said that these two yield attributing characters have helped to increase yield ratio significantly (Table 1). *Butea* is a light demanding crop (Faviah et al. 2018). Thereby, growth of tree was satisfactory in uplands due to relatively better sunshine attenuation. At the same time, lower humidity and higher sunshine might have favoured higher lac production. Residual bio-mass data can explain properly in favour of positive growth in uplands (Tab 1). These two factors might have played instrumental role for augmenting growth of the tree and thereby a satisfactory lac production was achieved in upland condition.

Effect of fertility levels: Fertility levels could not influence lac yield ratio significantly. Value ranged in between 3.06 (control) and 3.95 (recommended dose). Probable reason behind the result could be strongly acidic soil condition and age of the plantation. It is well established that availability of majority of nutrients decreases drastically when soil acidity increases. Yield ratio may be considered a reflection of shoot succulence, phloem sap enrichment and potassium uptake (Thakur 1932; Venugopal 1929; Fennah 1959; Ghosal 2017). Host specificity could be another reason of non-response to fertility levels, as the author witnessed a positive response (Ghosal 2012) of these nutrients on lac yield in *ber* (*Z. mauritiana*)

Effect of rest: Result of presented lac yield ratio affected by different rest periods is very interesting. A rest period of longer duration (19 months) could produce 4.78 times more broodlac compared to 2.25 times in shorter rest period (Fig 1). Thus, only by managing rest period, one can harvest 2.12 times more lac by opting rest period of 19 months. Corresponding values for encrustation thickness and percent shoots with lac were higher in longer rest period *i.e* 8 and 7 percent, respectively (Tab 1). In this case, two important factors worked simultaneously in favour of rest period of longer duration—*i.e.* more percent of shoots with settled lac and higher value of encrustation thickness. However, higher sticklac production obtained in shorter rest period could be due to more lac settlement on shoots.

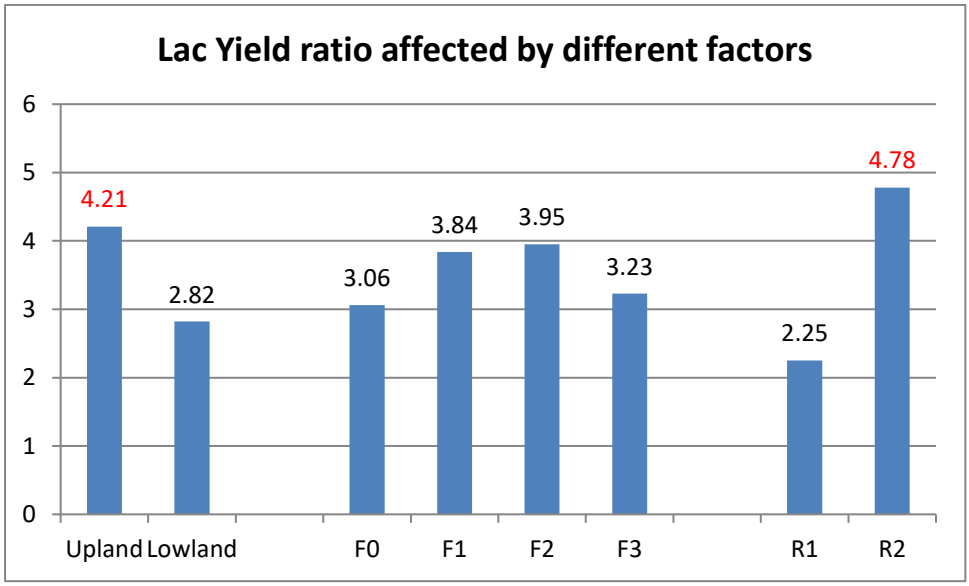

Fig 1: Lac yield ration influenced by topography, fertility and rest periods

F0: No fertilizer, F1: Lime 2kg/ tree, F2: (RD) Lime 2kg, NPK @ 200, 150 500 g/ tree and FYM 25kg/tree; F3: Double the RD

R1: Pre-pruning rest of 7 months; R2: Pre-pruning rest of 19 months

NB: Coloured font indicates significantly higher values

Tree growth:

Effect of topography: Residual bio-mass weight per 10 cm trunk diameter values as presented in Fig. 2 showed that values are significantly higher in uplands (3.29 kg/ 10 cm trunk diameter) than that in lowlands (2.36 kg/ 10 cm trunk diameter). Upland condition could register an increase of 39 percent over lowlands. Values on this parameter is actually a reflection on tree growth. As discussed earlier, upland condition is attributed to lesser water vapour and lesser floating particles in atmosphere over the lowland condition. As a result, the former received more sunshine. Thereby, trees could be able to produce more photosynthate than lowland condition. Moreover, the tree likes sunshine very much (Faviah et al. 2018). Experimental results gave a very clear cut mandate that plant growth condition for *palas* is far better in upland than lowlands. Due to longer submergence of rhizosphere, tree roots suffocated suffocation and thereby could not perform satisfactorily to uptake nutrients. Thus, immediate effect of the same was reflected on reduced tree growth.

Effect of soil fertility levels: Residual bio-mass weight did not vary significantly among different soil fertility levels. Range of variation remained between 2.31 (in control) to 3.66 kg/ 10 cm trunk diameter (in recommended dose). Keeping in mind the stubborn fertility condition of strongly acid soil, treatments considered were comprised of various kinds of sources of nutrients—*e.g.* lime, FYM, chemical fertilizers *etc*. But none of these treatments could show any effect on tree growth. Highest dose of fertility levels performed even inferior to the recommended dose. Most likely, reason of non-response could be strong acidic soil condition and age of the plantation. New growth of roots is very less in old plantations. As a result, uptake of nutrients suffered. The same has been reflected in this experiment.

Effect of rest period: Residual bio-mass weight was found to be 84 percent more in lesser rest period (7 months) than that in longer rest period. Main reason behind the fact could be inverse lac yield and bio-mass production relationship. Data showed an increase of 2.12 times in yield ratio in higher rest period as compared to lower rest. Therefore, for achieving higher lac production in 19 months rest, there had been a great reduction in plant growth/ bio-mass.

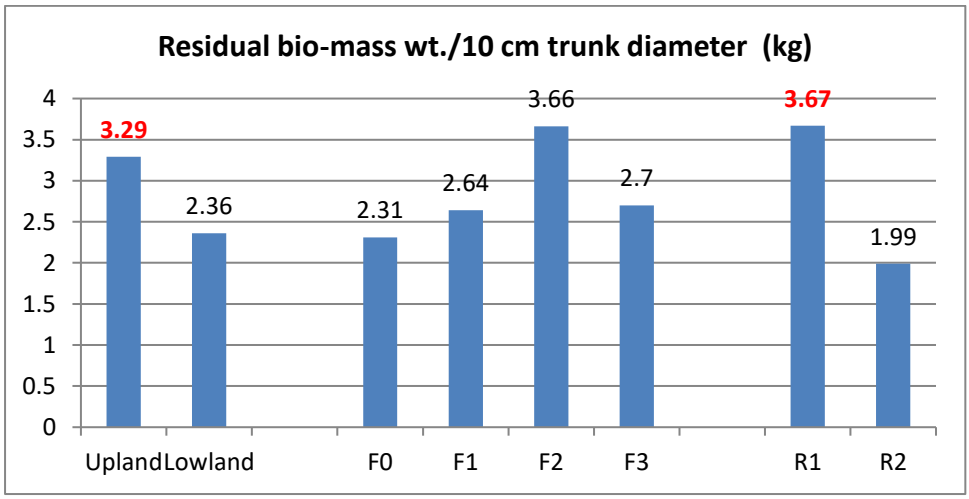

Fig 2: Lac yield ration influenced by topography, fertility and rest periods

F0: No fertilizer, F1: Lime 2kg/ tree, F2: (RD) Lime 2kg, NPK @ 200, 150 500 g/ tree and FYM 25kg/tree; F3: Double the RD

R1: Pre-pruning rest of 7 months; R2: Pre-pruning rest of 19 months

NB: Coloured font indicates significantly higher values

Lac yield attributes:

Effect of topography: Broodlac/ sticklac weight per unit length and lac encrustation thickness (mm) were recorded during harvesting. Upland condition showed an increasing trend in all the parameters over lowland. Out of these, sticklac weight per 10 cm length was 2.18 and 1.87 g. Difference observed was significant.

Effect of rest: Unlike lac yield ratio, sticklac and broodlac weight per unit length was found to be significantly higher in shorter rest period (7 months). Lesser rest period recorded 45 percent and 42 percent higher values for sticklaclac and broodlac weight values than that of longer rest (19 months). It is further to clarify that higher yield ratio despite of lower values in brood and sticklac weight per unit length was attributed to higher percent of lac infested shoots in longer rest and also due to higher values in encrustation thickness.

Longer rest period registered higher yield ratio and also higher number of infested shoots. It could be attributed to attaining specific texture of such shoots where preference of lac insect settlement worked favourably. Allowing longer rest period, might have enriched the shoots with quality phloem sap.

Predator/ parasite count:

Effect of topography: Predator/ parasite population within lac encrustation are very important parameters to emphasise for quality broodlac production. Broodlac quality deteriorates when these enemy insect population rises in a culture. In our study, it is clear that factors like topography and fertility levels did not show any significant effect on predator/ parasite population. But, rest periods could show a very prominent effect on predator population. Total number of predators (*Eublemma amabilis* and *Pseudohypatopa pulverea*) count was found to be 0.22 and 5.56 per meter length of broodlac. Bhattacharya (2011) discussed that these predators are attracted significantly when population density of lac insect in certain area increases. Or, in other words, it can be said: when lac inoculation is done at a higher rate. In our case, better growth of lac was found in case of longer rest period since it recorded 8 percent thicker encrustation than that of lesser rest period. That could be the reason why higher population of predators was found in higher rest period.

Residual soil fertility:

Important soil fertility parameters like pH, nitrogen and potassium content affected by different factors are presented in Table 1. Upland condition could raise soil pH to 5.48 against 5.19 in lowland condition. While potassium content in upland was found to increase 21 percent over lowland. Difference observed was found to be significant with respect to both the parameters. In fact, soil of the plots were in the category of clay to clay loam and soil sampling for soil test was done from 20-30 cm depth. Ernani et al. (2007) while experimenting on clay/ clay loam soil found out that leaching of potassium can be at 10-20 cm deep down the soil profile. This observation gives a proper justification as to why yearly addition of potassium fertilizer accumulated just below the plough layer. This phenomena might have increased availability of potassium to the shrubby tree like *palas*. Thus enhanced uptake of potassium might have increased lac production (Ghosal 2017).It was also noticed that treatments comprising of potassium achieved higher potassium levels. It indicated that potassium is not a mobile element in clay/ clay-loam soils and thereby, its loss after application is minimum.

Table 1: Lac yield, yield parameters and residual soil fertility of *palas* trees affected by land topography, fertility levels and rest period

	Dry Matter per cent	Sticklac wt per 10 (cm)	Brood lac wt per 10 (cm)	Av Encrustation thickness (mm)	Male percent	No. Predator/ m length	No. Parasite / m length	Per cent shoot with lac	pH	Nitrogen (kg ha^{-1})	Potash (kg ha^{-1})
Upland	33.34	2.18	6.76	4.22	26.97	3.25	7.77	69.20	5.48	263.87	504.00
Lowland	33.00	1.87	6.26	3.99	27.08	2.53	5.17	69.20	5.19	292.90	415.33
SEM±	0.76	0.17	0.50	0.14	1.50	1.11	2.66	2.89	0.06	18.25	21.83
$CD_{(0.05)}$	1.06 NS	0.24*	0.70	0.20	2.08	1.54 NS	3.69 NS	4.01 NS	0.09*	25.27 NS	30.23*
F0	32.81	2.11	7.49	3.98	28.76	2.81	3.88	59.40	5.33	285.87	366.33
F1	33.20	2.08	6.62	4.01	25.13	2.75	5.39	73.23	5.35	301.42	343.00
F2	33.68	1.89	5.80	3.94	28.05	4.25	6.15	70.92	5.32	272.49	492.33
F3	32.99	2.02	6.11	4.49	26.15	1.75	10.45	73.25	5.34	253.76	637.00
	1.08	0.24	0.71	0.21	2.12	1.57	3.76	4.09	0.09	25.81	30.88
$CD_{(0.05)}$	1.50 NS	0.34	0.99	0.29*	2.94	2.18 NS	5.22 NS	5.67*	0.13 NS	35.73 NS	42.76*
SEM±											
R1	33.09	2.40	7.66	3.95	25.41	0.22	6.24	66.92	5.37	269.98	462.00
R2	33.25	1.65	5.36	4.26	28.64	5.56	6.69	71.48	5.30	286.79	457.33
SEM±	0.76	0.17	0.50	0.14	1.50	1.11	2.66	2.89	0.06	18.25	21.83
$CD_{(0.05)}$	1.06 NS	0.24*	0.70*	0.20*	2.08*	1.54*	3.69 NS	4.01*	0.09 NS	25.27 NS	30.23 NS

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Declaration of interest statement:

It is declared that there is no clash of interest regarding ownership partially of fully in this paper

Data availability

Data will be available in PME Cell of ICAR-NISA, Ranchi

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Number of words in Supplementary Information:NA