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Research Article

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Calorific Values and Energy Structure of Different Parts of Three Varieties of *Dolichos Biflorus* L.In Jharkhand

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Abstract: *Dolichos biflorus L.* is commonly known as Horse gram and Kulthi in Hindi. It belongs to family Fabaceae. The seeds of *Dolichos biflorus* have several medicinal properties; anthelmintic, diaphoretic, diuretic, etc. as a well-enriched source of protein and energy. The calorific value and energy structure of *Dolichos biflorus* vary among the species. In this study, our aim was to evaluate the varieties of Kulthi for their better adaption and cultivation in the agro-climatic condition of Hazaribag, Jharkhand. Further, the variation in energy content of these varieties in the above agro-climatic condition. We have collected three varieties of Kulthi (Birsa Kulthi-1 to 3) for this study and followed for 105 days, to evaluate the energy content at different time intervals. We observed these three varieties of Kulthi are different in the relative amount of energy storage at maturity. However, all these three studied varieties of Kulthi (Birsa Kulthi-1 ,Birsa Kulthi-2 ,Birsa Kulthi -3) are ecologically suitable for cultivation in the vicinity of the agro-climatic condition of Hazaribagh, Jharkhand, India.

Keywords: Kulthi, Calorific concentration, *Dolichos biflorus,* Energy structure

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1. INTRODUCTION

Dolichos biflorus which belongs to the family fabaceae commonly known as horse gram or Kulthi, is a native to old world tropics and is extensively cultivated in dry areas in India, Australia, Myanmar, Sri Lanka and Himalayas.[1] Like moth bean, this crop is also drought tolerant and hardy. It is alsogrown to provide feed and fodder for cattle and especially for horses. Horse gram possesses various medicinal properties.[2,3] This Plant is an annual herb, slender, with slightly twining branches, semi-erect, low growing habit 30–50 cm high. Pods are short, 3–5 cm long, linear, with secured beak and 5–7 seeds.[4, 5] Seeds are flattened, rhomboidal 3–6 mm long, light red-brown, black or mottled. In India, it occupies 1.88 million ha with a production of 0.89 million tons[6, 7]. It is extensively grown in dry areas of Karnataka, Andhra Pradesh, Tamil Nadu, Maharashtra, and Gujarat, and in northern parts, it is cultivated in Madhya Pradesh, Himachal Pradesh and foot-hills of Uttar Pradesh, West Bengal and Assam hills[8]. Horse gram is extensively used in south India as feed for cattle and horses in the same ways as gram (*Cicerarietinum*) used in north India. The plant of horse gram can be grown in lateritic soil with moderately warm and in dry climatic condition with low rainfall. The heavy rainfall can affect nodule formation. The temperature of 25-30 ^{0}C with 50 – 80% humidity is an optimal condition for the growth of the plant. The plants are extremely drought resistant. The horse gram plant can be cultivated up to 1000m altitude. Hazaribag has enriched laetrile soil with low rainfall which is suitable for the cultivation of Kulathi varieties. Keeping in view the importance of crop in the area the present study was done to know the calorific concentration of different parts of Kulthi in agro- climatic conditions of Hazaribagh, Jharkhand, India

2. MATERIALS AND METHODS

The calorific values of different components of Kulthi varieties Birsa Kulthi–1, Birsa Kulthi–2 and Birsa Kulthi–3 were estimated from collected samples at the intervals of 15 days of the germination.

2.1 Sampling of plant material

Samplings of varieties of Kulthi i.e. Birsa Kulthi–1, Birsa Kulthi–2 and Birsa Kulthi–3 were sorted in the form of stem, leaf, inflorescence/pod, standing dead and root. The sampling threatened at an interval of 15 days.

2.2. Drying

The samples were dried at 80^{0c} until the weight of the samples was constant.

2.3. Milling and pelleting,

The dried materials were powdered and stored in plastic bags closed and labelled with sample numbers. Pellets of powdered samples were prepared by compressing it in a pellet press. In order to avoid incomplete combustion, the weight of pellets was kept below one gram i. e., between 0.6 to 0.9g.

2.4. Estimation of calorific values

Calorific values of plant samples were estimated by Parr Oxygen Bomb calorimeter.[9,10] The dried weighted pellets of plants were placed in the ignition cup of the bomb with the help of a nickel-chromium fuse wire. Further, the whole setup of Parr Oxygen Bomb calorimeter is submerged in water with 13-15 atmospheric pressure keeping the volume of water constant (1300mL) during the complete combustion process. The heat coming out during the combustion process is used for heating the calorimeter and the water inside the calorimeter. The change in temperature of the water during the combustion is used for calculation of calorific values.

3. STATISTICAL ANALYSIS

Graph Pad PRISM-5 was used for statistical analysis. Mean and standard deviation (SD) were used for inter column analysis. Significance between two groups was calculated by unpaired two-tailed and Mann Whitney u test. A p-value < 0.05 was considered significant.

4. RESULTS

4.1 Calorific concentration

Calorific concentration (cal/g) of different components of Kulthi varieties were analyzed during a period of 15 to 105 days. In the case of stem calorific value (cal/g) increased from 3106 cal/g (days 15) to maximum 3826 cal/g (days 60) and then started declining from 3725 cal/g in 75 days to 3510 cal/g in 105 days. Similarly, in the case of leaf calorific value beginning from 15 days onwards was 3815 cal/g and it reached peak value 4458 cal/g in 60 days. Further calories on day 75 was 4346 cal/g and day 105 was 3815 cal/g in the case of Inf./pod calorific value cal/g starts increasing from 60 days and reaches from a maximum in 105 days. Similarly, in the case of root calorific value cal/g on 15 days onwards 2983 cal/g increased in 90 days and decreased to 3515 cal/g in 105 days (Figure-1A to 1E). We have further evaluated the calorific concentration (cal/g) of different components of Kulthi variety Birsa Kulthi-2, age ranging from 15 days to 105 days. In the case of stem minimum calorific value, 3047 cal/g begins from 15 days and reaches its peak value 3729 cal/g in 60 days and then its start declining 3387 cal/g in 105 days (Figure-2A to 2E). Similarly, in the case of leaf and root also. Furthermore, we have evaluated the calorific concentrations (cal/g) of different components of Kulthi variety Birsa Kulthi-3 during the same period (15 to 105 days). In the stem at the age of 15 days' calorific value, cal/g was 2998cal/g. It reaches maximum 3604 cal/g in 60 days and then it starts declining and reaches at least calorific value 3284 cal/g in 105 days (Figure-3A to 3E). In the same way, it occurs in leaf, inf./pod and root.

4.2. Energy structure

Data of energy structure were presented in Table 1, 2 and 3 for varieties Birsa Kulthi–1, Birsa Kulthi–2 and Birsa Kulthi–3, respectively and expressed in Kcal/m^2. The energy structure in the stem increased from 0.15 Kcal/m^2 to 121.91 Kcal/m^2 in Birsa Kulthi–1 (Table-1), 0.09 Kcal/m^2 to 111.79 Kcal/m^2 in Birsa Kulthi–2 (Table-2) and 0.05 Kcal/m^2 to 104.10 Kcal/m^2 in Birsa Kulthi–3 between 15 to 90 days (Table-3), respectively. Later on, it decreased to 117.93 Kcal/m^2 in Birsa Kulthi–1, 101.03 Kcal/m^2 in Birsa Kulthi–2 and 86.63 Kcal/m^2 in Birsa Kulthi–3 at 105 days' harvest (Tables 1, 2 and 3). Energy structure in leaf increased from 0.45 Kcal/m^2 to 86.54 Kcal/m^2 in Birsa Kulthi–1, 0.33 Kcal/m^2 to 69.86

Kcal/m^2 in Birsa Kulthi–2 and 25 Kcal/m^2 to 52.58 Kcal/m^2 in Birsa Kulthi–3 between 15 to 90 days harvest. Later on, it decreased to 66.41 Kcal/m^2 in Birsa Kulthi–1, 54.42 Kcal/m^2 in Birsa Kulthi–2 and 40.70 Kcal/m^2 in Birsa Kulthi–3 at 105 harvests (Tables 1, 2 and 3). Energy structure in inflorescence/Pod increased from 6.58 to 202.12 Kcal/m^2 in Birsa Kulthi–1, 4.26 Kcal/plant to 131.99 Kcal/m^2 in Birsa Kulthi–2 and 2.30 to 88.36 Kcal/m^2 in Birsa Kulthi–3 between 60 to 105 days' harvest (Tables 1, 2 and 3). Energy structure in standing dead part of Birsa Kulthi–1, Birsa Kulthi–2 and Birsa Kulthi–3 at final harvest i.e. 105 days was found to be 45.29 Kcal/m^2, 33.81 Kcal/m^2 and 18.50 Kcal/m^2, respectively (Tables 1, 2 and 3).

Table 1. Standing crop energy (Kcal/$m^{2)}$ of different components of Kulthi variety Birsa Kuthi -1

Age (Days)	Stem Mean ± SD	Leaf Mean ± SD	Infl./Pod Mean ± SD	Standing dead Mean ± SD	Root Mean ± SD
15	0.15 ± 0.02	0.45 ± 0.10	–	–	0.05 ± 0.002
30	1.31± 0.17	2.84± 0.12	–	–	0.57 ± 0.25
45	8.24 ± 0.28	11.66 ± 0.28	–	–	2.32 ± 0.27
60	56.16 ± .2.52	35.70 ± 2.57	6.58 ± 0.32	–	9.32 ± 1.5
75	91.85 ± 2.12	50.89 ± 2.12	44.95 ± 7.5	–	19.48 ± 2.7
90	121.91 ± 7.9	86.54 ± 47.29	91.50 ± 7.9	23.50 ± 4.5	44.58 ± 8.0
105	117.93 ± 2.6	66.41 ± 2.64	202.12±11.15	45.29 ± 6.7	34.86 ± 4.7

biomass (mean ± SD) of Kulthi variety-1 (n = 05) during study period (0 day to 105 days) [Inf. = Inflorescence]. It should be up to SE.

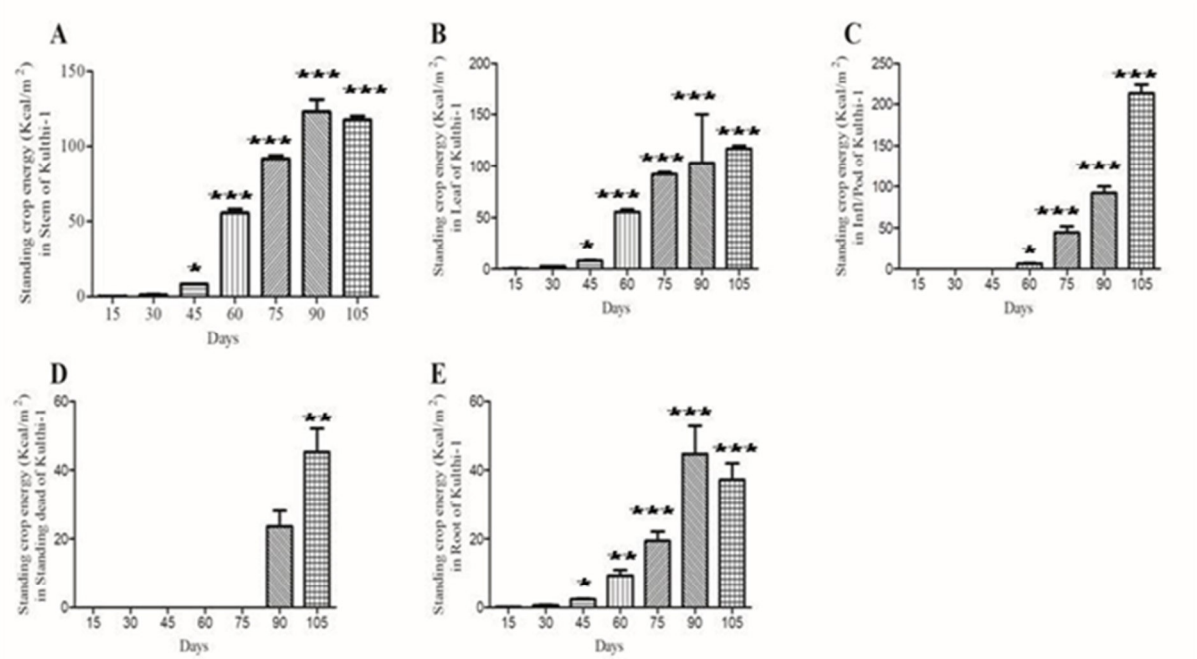

Fig-1: The bar diagram (mean ± SD) showing the change in biomass (mean ± SD) of Kulthi variety-1 (n = 05) during the study period (0 day to 105 days). The base diagram showing the statically difference of energy content in different parts of plants line A) Stem B) Leaf C) Inflorescence/Pod D) Standing dead crop and E) Root. Significant values depicted in figure with star. For one star (*) P= 0.05, for two star (**) p < 0.01 and three star (***) p <0.0001.

Table -2 : Standing crop energy (Kcal/$m^{2)}$ of different components of Kulthi variety Birsa Kuthi -2

Age(Days)	Stem Mean ± SD	Leaf Mean ±SD	Infl./Pod Mean ± SD	Standing dead Mean ± SD	Root Mean ±SD
15	0.09 ± 0.12	0.33 ± 0.13	–	–	0.02 ± 0.01
30	1.06 ± 0.06	2.45 ± 0.28	–	–	0.41 ± 0.06
45	6.48 ± 0.97	9.73 ± 1.02	–	–	1.78 ± 0.19
60	43.55 ± 5.9	28.96 ± 6.9	4.26 ± 1.1	–	7.00 ± 1.4
75	76.96 ± 10.3	43.54 ± 4.2	25.01 ± 5.4	–	16.46 ± 1.7
90	111.79 ± 11.4	69.86 ± 6.6	60.11 ± 9.0	17.23 ± 3.5	35.98 ± 5.6
105	101.03 ± 8.24	54.42 ± 8.3	131.99 ± 11.7	33.81 ± 5.2	29.22 ± 5.7

biomass (mean ± SD) of Kulthi variety-2 (n = 05) during study period (0 day to 105 days) [Inf. = Inflorescence]. It should be upto SE.

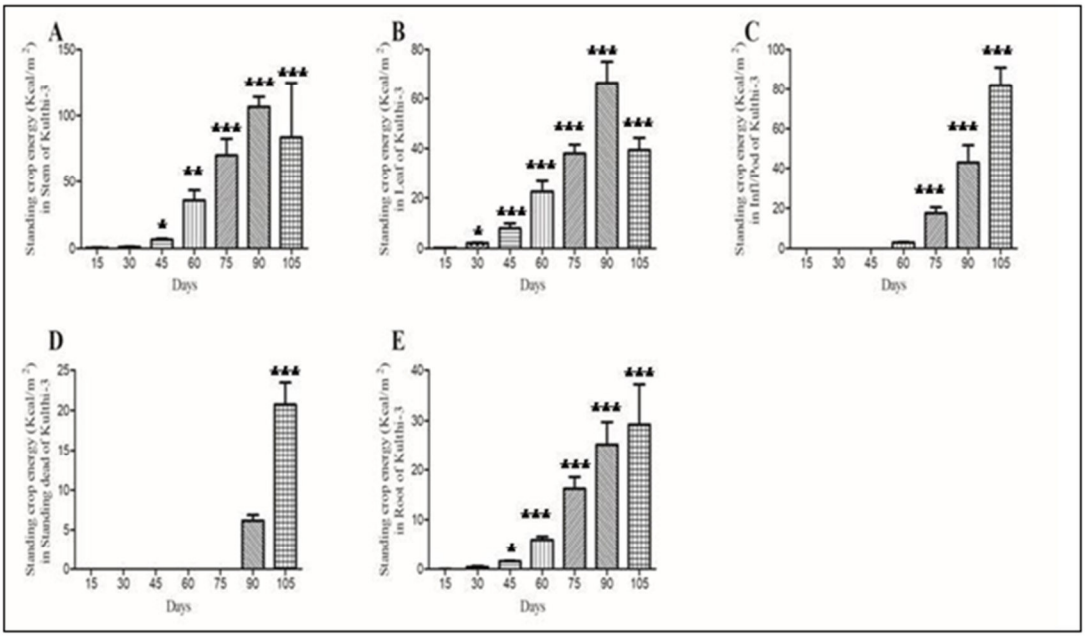

Fig 2: The bar diagram (mean ± SD) showing the change in biomass (mean ± SD) of Kulthi variety-2 (n=05) during the study period (0 day to 105 days). The base line for statically evaluated were used was 30 days in case of stem, leaf, Inf./pod and root. Further, the base line for statically evaluation for standing dead select was 90 days post seeding. Significant values depicted in figure with star. For one star (*) P= 0.05, for two star (**) p < 0.01 and three star (***) p <0.0001

Table-3 : Standing crop energy (Kcal/m²) of different components of Kulthi variety Birsa Kuthi -3

Age (Days)	Stem Mean ± SD	Leaf Mean ±SD	Infl./Pod Mean ± SD	Standing dead Mean ± SD	Root Mean± SD
15	0.05 ± 0.002	0.25 ± 0.03	–	–	0.02 ± 0.01
30	0.86 ± 0.11	1.91 ± 0.15	–	–	0.35 ± 0.13
45	5.10 ± 0.7	7.51 ± 2.0	–	–	1.58 ± 1.6
60	37.01 ± 7.6	22.12 ± 4.3	2.30 ± 0.32	–	5.39 ± 0.6
75	66.32 ± 12.5	33.19 ± 3.4	16.72 ± 3.0	–	14.66 ± 2.3
90	104.10 ± 7.75	52.58 ± 8.5	40.07 ± 8.7	7.75 ± 5.2	27.60 ± 4.4
105	86.63 ± 41.6	40.70 ± 4.9	88.36 ± 9.1	18.50 ± 17.4	22.45 ± 7.9

biomass (mean ± SD) of Kulthi variety-3 (n = 05 days) during study period (0 day to 105 days) [Inf. = Inflorescence]. It should be up to Mean± SD

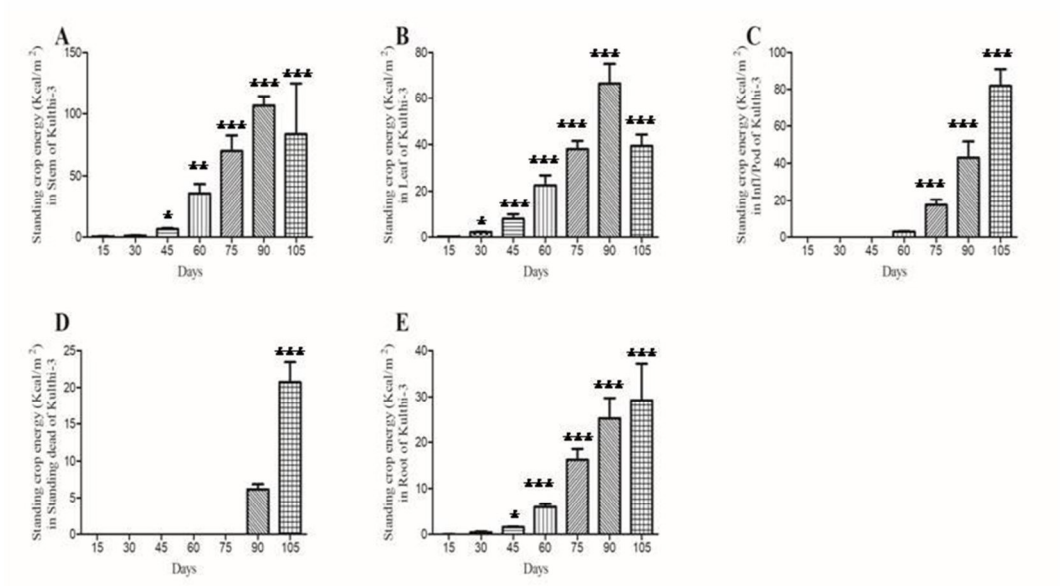

Fig-3: The bar diagram (mean ± SD) showing the change in biomass (mean ± SD) of Kulthi variety-1 (n=05) during the study period (0 day to 105 days). The base line for statically evaluated were used was 30 days in case of stem, leaf, Inf./pod and root. Further, the base line for statically evaluation for standing dead select was 90 days post seeding. Significant values depicted in figure with star. For one star (*) P= 0.05, for two star (**) p < 0.01 and three star (***) p <0.0001.

4.3. Mean and current increments in energy

Trends of the mean and current rate of energy accumulation were found similar in three varieties such as Birsa Kulthi–1, Birsa Kulthi–2 and Birsa Kulthi–3 of *Dolichosbiflorus*L. (Tables 1,2 and 3). The mean increment rate of energy was found to be increasing between 15 and 105 days. It has increased from 0.04 Kcal/m^2/day to 4.44 Kcal/m^2/day in Birsa Kulthi–1, 0.03 Kcal/m^2/day to 3.33 Kcal/m^2/day in Birsa Kulthi–2 and 0.02 Kcal/m^2/day to 2.44 Kcal/m^2/day in Birsa Kulthi–3 (Tables 1, 2 and 3). The current increment rate of energy increased from 0.27 Kcal/m^2/day to 6.57 Kcal/m^2/day in Birsa Kulthi–1 between 30 to 90 days, 0.23 Kcal/m^2/day to 3.70 Kcal/m^2/day and 0.18 Kcal/m^2/day to 1.63 Kcal/m^2/day in Birsa Kulthi–2 and Birsa Kulthi–3 between 30 and 105 days respectively (Tables 1, 2 and 3).

5. DISCUSSION

Hazaribag is a tribal area of Jharkhand. The land areas of Hazaribag were divided into a big upper land area; which was barren with enriching of laterite soil, high humidity, less rain falls with high altitude and a small lower land area; situated on the bank of rivers are fertile. This small fertile area is not sufficient to fullfill the food requirement of Hazaribag. So there are two alternatives to full fill the food requirement in that area. First, to use a huge amount of fertilizers and irrigation in the barren area to cultivate the crops or second to adopt the alternative crop which is/are suitable for cultivation in that specific agro-geo climatic condition. The first option is not sustainable for a long time, but the second option is better to adopt. Horse gram is one of the alternative crops, that can use for fulfill the food requirement. We have evaluated the different varieties of horse gram for their energy content. The caloric value of the plant material depends upon the quality and quantity of food reserve in its. The energy content of a plant is governed by its genetic constitution, stage in the life history and nutritive status, especially the fat content.[11] Fat is the richest source of energy and upon complete combustion yields an average of 5700 cal/g, whereas carbohydrates and proteins yield only 4100 cal/g and 4900 cal/g, respectively.[12] Therefore a slight variation in the percentage of fat would cause a remarkable change in the energy value of the plant materials. Storage and conversions of different organic compounds in different plant parts are strongly related to climatic factors and life cycle stage. Therefore, environmental conditions play an important role in influencing these factors. A seasonal variation in the caloric value varies with light intensity, length of the day, amount of nutrients and type of soil in which plants grow. It has been observed that the energy concentration in vegetative parts has increased with age till flowering. Later on, it has decreased in all the vegetative parts till final harvest. The energy concentration in the pod was found to be increasing right from its initiation to its maturity. This trend of variation of energy concentration in different plant parts is attributed to the changing ratio of fat, carbohydrate and protein in the dry matter. Fat is the richest source of energy. The energy content and its distribution pattern in the plant are governed by its genetic ability, development stages of plants and environmental complex.[13] Fluctuations in calorific concentration with changing composition of organic matter has been noticed in several varieties of plants.[14] In this study we observed the trend of calorific concentration in plant parts of variety Birsa Kulthi–1, Birsa Kulthi–2 and Birsa Kulthi–3 as: Inflorescence / Pod>Leaf>Standing dead>Stem>Root. High calorific concentration in inflorescence/pod of variety Birsa Kulthi–1, Birsa Kulthi–2 and Birsa Kulthi–3 may be attributed to oil accumulation in the seeds.[15]

6. CONCLUSION

The above study concludes that the agro-climatic conditions in the surrounding of Hazaribag, Jharkhand is suitable for cultivation of varieties of Birsa Kulthi (*Dolichosbiflorus*). Further, the biomass of stem and leaf of Birsa Kulthi varieties reached a maximum at day 90, after that the biomass starts decreasing. At the same time, the biomass of inflorescences/ pods starts increasing. Energy accumulation pattern of variety Birsa Kulthi-1, Birsa Kulthi-2, Birsa Kulthi-3 reveals that the accumulation capacity of different organs in different varieties Change with developmental stage. Obviously, the age of the plant affects the dry matter production with may finally decline the energy storage in plant parts at various stages of growth

7. ACKNOWLEDGEMENT

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8. AUTHORS CONTRIBUTION STATEMENT

P Kumar, R Kumar and RRK Sinha all equally contributed to conceptualizing this study. Further, P Kumar and R Kumar collected the samples, performed all the experiments, analyzed the data and wrote the manuscript. RRK Sinha reviewed the manuscript. All authors read and approved the final manuscript.

9. CONFLICT OF INTEREST

Conflict of interest declared none.

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