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Advantages of De-oiled Castor cake in Agriculture

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ABSTRACT

The soils of India are poor in availability of plant nutrients. As about 97 per cent of soil samples analysed were deficient in nitrogen, 83 per cent soil samples in phosphorus and 71 per cent in potash. Oil cakes are rich in fibre, protein and energy contents. Castor cake is the primary by-product generated after castor oil production from castor bean plant (*Ricinus communis* L.). In general, one tonne of castor oil production results in 2.4 tons of castor cake by-product. This is due to castor cake has a high nitrogen content and a low carbon to nitrogen ratio, and the nitrogen in castor cake can be readily mineralized and available for plant uptake once applied to soil, which makes castor cake an excellent nitrogen source for organic farming. Each tonne of Castor De oiled cake contains nearly: 45 kg nitrogen (approx. 90 kg urea; 46 %N); 10 kg phosphorus (22 kg DAP; 18 % N; 46 % P₂O₅) and 10 kg potash (17 kg MOP; (60 % K₂O), close to 130 kg of fertilizers urea + DAP + MOP. The castor meal or de oiled cake are suitable for cereals, pulses, sugarcane, cotton, banana, castor, vegetables, spices, floriculture, medicinal plants, plantation crops in general and high value export-oriented crops or organic farming in particular.

Keywords : Castor cake, Deoiled cake, Nitrogen, Organic farming, Integrated Nutrient Management, Soil Carbon

INTRODUCTION

Out of 118 known elements, plants require only 17 elements for their growth and development. These elements are known as essential plant nutrients. These can be grouped as: Basic nutrients (carbon, oxygen and hydrogen); Primary nutrients (nitrogen, phosphorus and potassium); Secondary nutrients calcium, magnesium and sulfur); Micro nutrients (iron, manganese, zinc, copper, boron, molybdenum, chlorine, and nickel). Primary nutrients are required in larger quantities than the secondary nutrients. The micro nutrients are required in traces for growth

and development of plants. The soils of India are poor in availability of plant nutrients. As about 97 per cent of soil samples analysed are deficient in nitrogen, 83 per cent soil samples in phosphorus and 71 per cent in potash. Close to half of the soil samples are deficient in either sulphur or micronutrients like B, Zn and Fe, etc. It is remarkable that 85 per cent of Indian soils are also deficient in organic carbon (Anonymus, 2022). The carbon plays a central role in balancing physical, chemical and biological properties of soil. Under this condition, it becomes necessary that the nutrient should be added very carefully. The plant nutrient addition should benefit the soil

immediately and increase nutrient reservoir on long term basis.

Looking to the food production from, India has witnessed in quantum jump in food grain production after adopted the initiatives of green revolution in the decade of 1960s. Presently, India produces around 320 million tonnes of food grains annually. That is almost 3.85 times of the production level of 1960-61. Similar trend was observed in the total fertilizer consumption. The fertilizer consumption has reached to 29.8 million tonnes in 2021-22. That is nearly 103 times to the fertilizer consumption level of 1960-61. This shows our agriculture is much dependent on externally addition of nutrients or fertilizers. The production of fertilizer nutrients is limited in India. There is a gap in fertiliser production and consumption in India. The gap is bridged through imports of fertilisers. The fertiliser import is a dent to forex reservoir of country. Last year India has imported 9.82 million tonnes of fertilizers. The gap between total fertilizer consumption in India and import of fertilizers is widening.

The ray of hope is found in use of oilmeals as nutrient source.

Organic residues are widely used as supplement to chemical fertilizers because they provide nutrition to plants, improve the physical and chemical properties of soil (Hafez, *et al.*, 2021), and promote microbial activity in soil (Shilpa shree, *et al.*, 2022). Oil cakes are rich in fibre, protein and energy contents. Castor cake is the primary by-product generated after castor oil production from castor bean plant (*Ricinus communis L.*). Castor oil contains around 75 to 89 per cent of ricinoleic acid, $C_{18}H_{34}O_3$, is structurally known as *cis*-12-hydroxyoctadeca-9-enoic acid, a 18-carbon

hydroxylated fatty acid having one double bond, which makes castor oil exceptional and highly demanded on the international market (Conceicao *et al.*, 2007). Therefore, castor oil has been extensively used for medical and personal care purposes (e.g., as anti-inflammatory drug), industrial applications (synthesis of coatings, paints, inks, etc.), and biodiesel production (starting material) (Deshmukh *et al.*, 2022) and also for ethanol production.

In general, one tonne of castor oil production results in 2.4 tons of castor cake by-product (Lima *et al.*, 2011). India the global leader in castor production - 1.65 million tonne of castor seed and after extraction that will generate nearly 0.83 million tonne of castor meal (DOC) annually. The predominant method for castor oil extraction consists of expeller press followed by solvent extraction. The by-product of this process of is called 'cake' when only the expeller press is used and 'meal' or de-oiled castor cake when the solvent extraction is used. The castor cake contains about 10-12 per cent oil while the castor meal or de-oiled cake contains hardly 0.5 per cent oil (Fig 1). Amino acid profile of castor cake is given in Table 1.

The castor cake contains around 98 per cent dry matter, with nearly 25 per cent soluble carbohydrates. The amino acid profile of castor cake is closely related to the soybean. However, the castor cake is deficient in certain indispensable amino acids like iso-leucine, tryptophan, lysine. Besides this the castor cake also contains around 72 ppm iron, 8.08 ppm manganese, 5.33 ppm copper, and cobalt 1.64 ppm (Annongu and Joseph, 2008).

Table 1: Amino acid profile of castor cake

Amino acid, g/16gN	Castor cake	Soybean
Lysine	4.11	6.30
Histidine	1.38	2.70
Arginine	8.00	8.10
Aspartic acid	6.42	11.80
Threonine	3.00	3.90
Serine	2.13	5.20
Glutamic acid	13.19	17.90
Proline	2.76	5.90
Glycine	0.56	4.40
Alanine	3.96	4.30
Cystine	0.53	1.60
Valine	5.46	5.10
Methionine	2.06	1.60
Iso-leucine	3.09	7.90
Leucine	5.90	5.10
Tryptophan	-	1.30

Although, castor cake is rich source of protein (~35%) (Anandan *et al.*, 2005) could not suitable to use as animal feed due to presence of toxins and allergens. The ricin, is protein, consisted of two chains (A and B) bonded by a single disulfide bond. Chain A is a ribosome-inactivating enzyme of 32 kDa, whereas chain B is a galactose/ N-acetylgalactosamine-binding lectin of 34 kDa. Both chains are required for the high toxicity of ricin and inhibition of protein assimilation in cells. Castor DOC contains is toxic to animals because it contains a toxic protein ricin varied from 1 to 5 per cent (Shah *et al.*, 2014; Mondal *et al.*, 2019); another reason for not use of ricin as feed is due to presence of ricinine ($C_8H_8N_2O_2$) or 3-cyano-4-methoxy-*N*-methyl-2-pyridone belongs to the group of piperidine alkaloids, content varies but contains 2.3–32.9 g/kg in leaves, 2.4 g/kg in stems, 3 g/kg in roots and 0.43–7.0 g/kg in seeds (Leite *et al.*, 2005; Xu *et al.*, 2007; Wen *et al.*, 2008; Cazal *et al.*, 2009). In addition, deoiled cake also

contains Ricinus Communis Agglutinin (RCA). RCA is a tetrameric protein with stronger agglutinating properties than ricin but is less toxic (Lord *et al.*, 1994; Bigalke and Rummel, 2005). Together these compounds make up around 5% of the total protein in the mature seeds. Therefore, not suitable for animal feed unless detoxified fully. Instead of feeding livestock, castor cake is more recommended to be used as an organic fertilizer (Lima *et al.*, 2011; Patel *et al.*, 2016; Severino *et al.*, 2012).

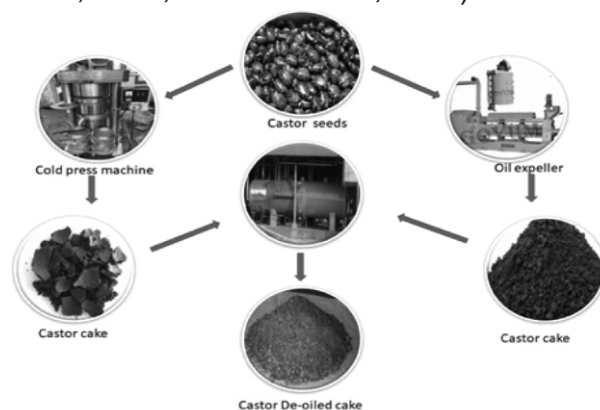


Fig 1: Systematic diagram of production of Castor DCO from castor seeds

The composition and nutritional availability of oil cakes widely vary based on the quality of the seed, method of oil extraction, storage parameters, etc. This is due to castor cake has a high nitrogen content and a low carbon to nitrogen ratio, and the nitrogen in castor cake can be readily mineralized and available for plant uptake once applied to soil, which makes castor cake an excellent nitrogen source for organic farming (Kulkarni *et al.*, 2018). Castor cake are also inhibiting the nitrification process. Therefore, increasing nitrogen usage by the crop. Applying organic fertilizers to soils for improving soil quality and crop growth is a promising practice for sustainable agriculture. Castor

cake has dual agricultural benefits of organic fertilizers and pesticides seem to synergistically support plant growth and prevent plant diseases (Ning *et al.*, 2017).

Specifications of Castor de-oiled cake:

As per The Fertiliser (Inorganic, Organic or Mixed) Control Order, (1985), the non-edible de-oiled cake fertiliser is defined as

“The substance obtained as residue after oil extraction (by expeller and/or through solvent extraction) from crushed seeds of nonedible oilseeds (Such as Castor, Neem, Karanj, Mahua and Jatropha for use in soil as fertiliser” (Biofertilizers and Organic Fertilizers in Fertilizer (Control) Order, 1985) (Table 2).

Table 2: Specifications of Castor de-oiled cake

Parameters	Castor DOC	Remarks
Moisture % (by weight)	12	Maximum
Ash content % (by weight)	15	Maximum
Total Organic Carbon % (by weight)	25	Minimum
Total Nitrogen (as N) % (by weight)	4.5	Minimum
Total Phosphorus (as P ₂ O ₅) % (by weight)	1.0	Minimum
Total Potash (as K ₂ O) % (by weight)	1.0	Minimum
pH	6.8-8.0	
Conductivity (as dSm-1)	4	Maximum

Roughly, each tonne of Castor De oiled cake contains nearly: 45 kg nitrogen (approx. 90 kg urea 46 %N); 10 kg phosphorus (22 kg DAP 18 % N, 46 % P₂O₅) and 10 kg potash (17 kg MOP (60 % K₂O), close to 130 kg of fertilizers urea+ DAP+MOP. The N content of de-oiled cake mineralize rapidly. On decomposition,

enzymes, hormones, antioxidants, vitamins and plant growth promoting substances are produced.

The castor cake is being used as source of nutrients in many areas of India, the scientific study on integration of castor cake with chemical fertilisers was conducted by many researchers (Table 3).

Table 3: Selected references for integrated use of castor cake for crop production.

State	Crop	Location/District	Dose of Castor DOC	Reference
Andhra Pradesh	Papaya Nursery management	Anantharajupeta, YSR	10 g /nursery bag	Lakshmi Devi <i>et al.</i> , 2020
Delhi	Sunflower-maize	Delhi	50 % of RDN	Yadav <i>et al.</i> , 2007.
Karnataka	Rice	Raichur, Dhadesugoor	0.5t/ha	Ramesha <i>et al.</i> , 2017
Maharashtra	Rice	Kolhapur	25 % of RDN	Sharma <i>et al.</i> , 2016
Punjab	Maize	Ludhiana	33 % RDN	Patidar <i>et al.</i> , 2018
Rajasthan	Potato	Bikaner	3 t /ha	Meena and Gupta (1996)
Tamil Nadu	Greengram	Tiruchirappalli	0.5 t/ha	Kalaiyarasi <i>et. al.</i> , 2019
Tamil Nadu	Medicinal COLEUS	Sirukalathur, Ariyalur	2 t/ha	Muruganandam <i>et. al.</i> , 2021

Gujarat being the topmost castor producing state in India having most of castor oil extracting units located in Gujarat, the availability of castor cake, therefore, the

research on different crops has been conducted and farmers are using castor cake in their field (Table 4).

Table 4 : Selected references for integrated use of castor cake for crop production in Gujarat.

Crop	Location/District	Soil Type	Dose of Castor DOC	Reference
Groundnut	Dantiwada-Banaskantha	Loamy sand	1.0 t/ha	Bhutadiya <i>et al.</i> , 2019
Custard apple	Anand	Loamy sand	4.0 kg/plant (11 yr old plant)	Jangid, <i>et al.</i> , 2021
Pearl millet	Navsari	Clayey	2 t/ha	Barad, <i>et al.</i> , 2017
Coriander	Dantiwada-Banaskantha	Loamy sand	0.5 t/ha	Nisarata 2022
Potato	Deesa-Banaskantha	Loamy sand	50 % of RDN	Kanbi and Bhatanagar (2005)
Garlic	Danti-Umbharat, Navsari	Clayey	50 % of RDN	Joshi <i>et al.</i> , 2019
Sugarcane	Navsari	Clayey	1t/ha	Patel <i>et al.</i> , 2009
Sorghum	Anand	Loamy sand	25 % of RDN	Yadav P.C., Sadhu A.C., Swarnkar P.K. 2007
Ashwagandha	Anand	sandy loam	2.5 t/ha	Jat <i>et al.</i> , 2021
Kalmegh	Anand	sandy loam		Basak, <i>et.al.</i> , 2020
Chrysanthemum	Junagadh	Medium black	0.88t/ha	Palagani, <i>et. al.</i> , 2013
Cotton	Junagadh	Medium black	0.5 t/ha	Vekaria, <i>et.al.</i> , 2022
Cowpea	Dantiwada-Banaskantha	Loamy sand	50 % of RDN	Birla and Patel, 2022
Blackgram	Devghadh Baria, Dahod	sandy loam	0.12 t/ha	Patel <i>et. al.</i> , 2022
Chickpea	Anand	sandy loam	0.5 t/ha	Shulka <i>et al.</i> , 2013
Wheat- forage cowpea	Anand	sandy loam	25 % of RDN	Suryawanshi, <i>et al.</i> , 2019
Tobacco	Anand	sandy loam	0.2 t/ha	Patel, <i>et. al.</i> , 2018

Recommendations based on national centre for organic and natural farming:

Castor cake could be a suitable source of nutrients under organic farming. Many researchers have studied the suitability of castor DOC under organic farming (Table 5) Fig 2.

National Centre for Organic Farming (NCOF) is a nodal organization for promotion of organic farming under INM Division, Department of Agriculture & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Government of India under Soil Health Management component of National Mission on Sustainable

Table 5 : Selected references for use of castor cake for crop production under organic farming.

Crop	State	District	Soil type	Reference
Field bean	Karnataka	Shivamogga	sandy loam	Shilpashree, <i>et al.</i> , 2022
Fenugreek	Gujarat	Dantieda	Loamy sand	Malav, <i>et. al.</i> , 2018
Onion	Gujarat	Navsari	Clayey	Naik, <i>et. al.</i> , 2014
Cotton	Maharashtra	Akola	Vertisol	Khuspure 2018

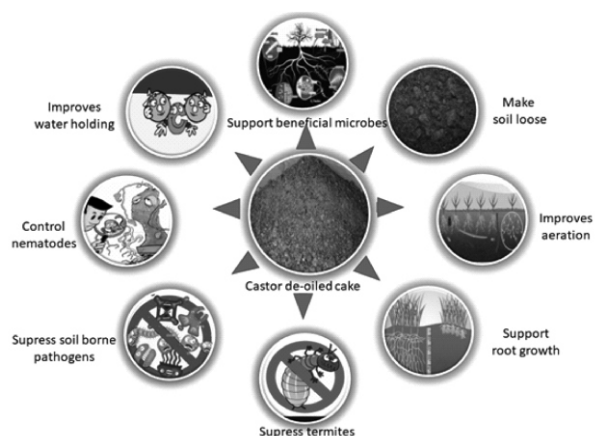


Fig 2: Use of castor cake for crop production

Agriculture. The package of practices under organic farming are provided on the website of the organization. Castor cake are

promoted to use for nutrient management or disease management or nematode control. For nutrient management it is crop and location (state) specific (Table 6). For nematode control under organic farming practices, soil application of 1 t/ha of castor cake is recommended in Gujarat for Garlic and Blackgram and in Kerala for Okra crop. Soil application of castor cake (0.5 t/ha) along with *Trichoderma viridi* is recommended to control Sclerotium Stem rot of Groundnut in Andhra Pradesh and Cotton wilt in Gujarat. Wheat weevil/ termites could be controlled by application of 1 t castor cake 2-3 days before sowing of wheat.

Table 6: Nutrient management under organic farming suggested by NCOF

State	Crop	Dose of castor cake	Crop	Dose of castor cake
Gujarat	Field crop		Horticultural crop/ plantation crops	0.2 -0.75 kg/plant
	Groundnut/ Sugarcane/ Potato/ Maize/ Moong bean/ Pigeon pea/ Castor/Sesame	1 t/ha	Rose /Custard apple/ Guava /Banana	
	Paddy/ Kalmegh/ Jivanti (Dodi)	2 t/ha	Mango / Pomegranate	2 - 5 kg/ plant
Madhya Pradesh	Wheat	0.3 -0.5 t/ha		
Tamil Nadu	Rice	0.1-0.2t /ha		
Odisha	Turmeric	2 t/ha		

(SOURCE: <https://ncof.dacnet.nic.in/Package of Practices> accessed on 06.03.23)

In different states the castor cake has been recommended as package of practices. In Punjab, soil application of castor cake @ 0.5 t/ha for onion and 1.5 t/ha for wheat and maize is recommended. In Andhra Pradesh for turmeric, application of 0.5 t/ha and for onion (Mananandi District) 2.5 t/ha castor cake is recommended.

Speedy nitrogen mineralization: The carbon to nitrogen ratio (C:N) is one of the most important factors affecting the decomposing rate of an organic material. The optimum C:N ratio for a material to be used for compost is in the range of 25–30 and different materials can be mixed in order to reach an adequate ratio (Kumar *et al.*, 2010). Castor husks are comparatively poor in N (1.86%) but rich in K (4.50%), while castor meal is rich in N (7.54%), but poor in K (0.66%).

Phosphorus management: Low phosphorus (P) use efficiency necessitates the high rate of P fertilizer application to achieve the desired crop yield. Castor cake may be alternative of costly inorganic P fertilizer. The application of castor cake promotes the phosphorus uptake. The difference occurred due to higher microbial biomass P and alkaline phosphatase activity due to application of castor cake (Basak, 2023).

Suitable for rainfed and salt affected soils: Castor can be grown easily in non-productive lands especially in rainfed area and in sodic land of subtropical and tropical locations that require low inputs. It can prevent desertification and erosion in marginal lands if grown there. It has capacity to tolerate salinity stress (Berman and Wiesman, 2011). Adequate nutritional supplementation with nitrogen (N) may be an alternative to mitigate the harmful effects

of salinity in plants mainly when provided as organic inputs. These N sources act on the osmotic regulation, ion compartmentation, and biosynthesis of osmoprotectants. The accumulation of osmoprotectants, such as sugars, proteins, and some amino acids, results in osmotic adjustment, reducing the water potential of cells and maintaining the water uptake even in soils with low water potential, as saline soils. In addition, these osmoprotectants can also scavenge reactive oxygen species and stabilize proteins and membranes, being important molecules for salt stress tolerance (Singh *et al.*, 2019). Application deoiled cake up to 5 t ha⁻¹ could mitigated the effects of moderate saline stress upto 3 dSm⁻¹ in basil. In addition, CBC induced osmoregulation under saline conditions, as shown by the increase in free amino acids, proteins, proline, glycine-betaine, and sugars.

Effect on microbial population: Soil health and productivity is directly related to soil microflora as it is an intimate part of soil organic matter and supports growth and development of different crops in many ways. The microorganisms present in the rhizosphere environment around the roots influence the plant growth and crop yield. The castor DOC resulted in higher production of root exudates and increasing the beneficial microbial population in rhizosphere of pulses (Table 7). The microbial population was maximum during the 60 days after sowing (Shilpashree, *et al.*, 2022).

Promotes soil mycorrhiza: Castor cake application favours the growth of mycorrhizal in the root rhizosphere. The favorable effect of addition on soil properties by the application of castor cake favour increased colonization by

Table 7: Influence of deoiled castor cake on soil microorganism population

Microflora	Bacteria (No. × 105)			Fungi (No. × 104)			Actinomycetes (No. × 103)			N-fixers (No. × 103)			PSM (No. × 103)		
Initial	5.67			2.33			3.00			3.67			4.33		
Treatments	30 DA S	60 DA S	At Har vest	30 DA S	60 DA S	At Har vest	60 DA S	At DA S	30 Har vest	60 DA S	At DA S	30 Har vest	60 DA S	At DA S	30 Har vest
Control	11.00	27.00	19.00	3.00	6.00	4.67	5.67	18.33	6.33	5.00	17.00	14.00	7.67	9.33	2.67
Castor cake	15.00	32.67	24.67	6.00	10.33	7.67	8.33	24.00	10.00	13.33	22.67	19.00	10.33	12.33	7.00
CD	2.73	1.35	1.32	1.64	1.35	1.22	1.15	1.30	0.73	1.17	0.93	0.95	0.90	1.41	1.02

Crop: Field bean; Initial soil pH: 6.45; OC % 0.40; Avail N; P₂O₅; K₂O: 140:30:140 kg/ha

Castor cake N 4.3 %, P 1.8 % and K 1.3 %

*DAS- Day after sowing

mycorrhiza. When brinjal seedlings were transplanted in castor cake amended soil, the nematode population densities both in soil and root significantly reduced and plant growth parameters were increased. Favourable effect was observed by castor cake amendment on the growth of *G. fasciculatum* in the rhizosphere of brinjal plant. The combined effect of colonization of *G. fasciculatum* on roots and castor cake amendment in the soil was responsible for the significant reduction of *M. incognita* infestation on transplanted brinjal plants (Jothi *et al.*, 2005).

Supporting nursery management:

Castor cake can serve a suitable potting mixing material for nursery raising. Castor deoiled cake can be used as a potential, effective, cheaper and non-polluting organic source of nitrogen and other growth promoting substances. It was found that the growth characters of papaya seedlings raised in the potting mixture enriched with castor cake, *T. harzianum* and A.M Fungi exhibited enhanced shoot length, stem girth, petiole length, petiole diameter, number of leaves, SCMR values, vigour index and leaf area or a vigorous healthy seedlings for quicker germination and for

production of healthy robust seedlings in just 45 days. Many researchers reported that using bio-fertilizers in addition to organic fertilizer led to improvement of vegetative growth and productivity of castor (Patel *et al.*, 2010).

Disease control: Ricin inhibits protein synthesis by acting mainly on eukaryotic ribosomes. So, fungi are more susceptible to it than bacteria. (Rashmi *et al.*, 2019). Deoiled castor cake was found effective in controlling several soil borne diseases. Soil application of castor-cake enriched *Trichoderma* (isolate T-170) at 50kg/ha (*Trichoderma* multiplied on sorghum grains and mixed with 50 kg castor-cake) + intercropping with maize (3:1 ratio) + gypsum at 500kg/ha at flowering + foliar application of Chlorothalonil effectively controlled collar rot, stem rot, early leaf spot and late leaf spot. *Trichoderma* isolate NRCG T12 enriched with castor-cake effectively controlled collar and stem rots, *A. flavus* infection and *aflatoxin* contamination. Annonymus, 2009.

Insect pest control: Castor cake, owing to its biochemical produced during the process of decomposition has reported to control *Agrotis ipsilon* (Potato cutworm)

when applied to the soil @ 2.5 q/ha (Manendra, 2016).

Nematode control : Use of castor cakes @ 1 tonne/ha has been found to reduce root-knot nematode damage in vegetables and groundnut (Khan *et al*, 2010). Their combinations with seed treatment of carbosulfan (25 DS) @ 3% a.i. (w/w) further improved efficacy in reducing the nematode population and enhancing the yield significantly. Castor deoiled cake suppress pathogenic nematodes because during decomposition volatile compounds (VOC) like phenol, 4-methylphenol, γ -decalactone, and skatole are produced. VOCs produced after the incorporation of castor bean cake in the soil resulted in immobility (>97.3%) and death (>96.9%) of *M. incognita* second-stage juveniles and reduction in *M. incognita* egg-hatch (>74.3%) (Pedroso *et al.*, 2019).

Challenge for use of castor cake is the time of application : Following De-oiled cake application to soil, a temporary toxic effect is occasionally observed for some days because of rapid mineralization, leading to the release of excessive N in the soil; however, the toxicity eases after 1-2 weeks (Lima, *et al.*, 2011, McKeon, *et. al.*, 2013). Higher dose of application or close contact with seed, reduce seedling emergence, impair plant growth, and even cause plant death could observe Roberto *et. al.*, 2011; also high concentrations of ricinine is poisonous to earthworms in soil (Liu *et. al.*, 2021). The de oiled cake should be applied at least three weeks before sowing of wheat and the field must be kept moist for the degradation of toxicants. This also helps to liberate phosphorus to the plants (Gupta *et al.*, 2004).

CONCLUSION

Castor meals are good source of nutrients especially nitrogen, phosphorus, potassium and micronutrients. The meals also act as soil conditioner. They improve soil fertility. Castor meals have ability to control disease and pest considerably. The castor meal or de oiled cake suitable for cereals, pulses, sugarcane, cotton, banana, castor, vegetables, spices, floriculture, medicinal plants, plantation crops in general and high value export-oriented crops or organic farming in particular.

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