Original Research Article

~~Assessment of~~ Physic~~al and C~~ocal ChemicalProperties~~ of~~ ~~Continuously~~ Long-term~~Cultivated~~ Rice-Fallow Cultivation and Uncultivated Soils of Nalbari ~~District~~, Assam

ABSTRACT

~~The present study was undertaken~~We aimed to assess the changes in physical and chemical properties of soils due to ~~long~~ long-term continuous cultivation of rice under a rice–fallow system and that was compared withadjacent uncultivated soils. Soil samples were collected from respective sites and ~~the~~ somesoil's physical (bulk density; BD, water holding capacity; WHC, and moisture content; MC) and chemical properties (pH,electrical conductivity; EC, organic carbon; OC, available N, available P,available K, exchangeable Ca, exchangeable Mg, available S, available Zn, and available B) ~~analyzed~~ were evaluated using descriptive statistics. The results indicated that the soils under cultivation with rice-fallow were significantly (P<0.05) higher in bulk density (1.40 Mg.m^{-3}) and lower inWHC(41.34%) than the adjacent uncultivated soils(BD=1.34 Mg m^{-3} &WHC=42.26%). ~~The values of s~~Soil's chemical properties~~(pH=5.51, organic carbon=0.63%, available N=245.56 kgha^{-1}, available P= 31.27 kgha^{-1},available K=120.98 kgha^{-1},exchangeable Ca=5.35 Cmol (p+) kg^{-1},available S=53.42 kgha^{-1}, available Zn=0.31 mgkg^{-1} andavailable B=0.41 mgkg^{-1})~~ were significantly (P<0.05)

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~~found~~lower incultivated rice-fallow soils than the uncultivated soils (pH=5.51 and 5.93, ~~organic carbon~~OC=0.63 and 0.89%, available N=245.56 and 418.37 kg.ha^{-1}, available P= 31.27 and 42.62 kg.ha^{-1}, available K=12098 and 145.90 kg.ha^{-1}, exchangeable Ca=5.35 and 5.93 C mol (p+) kg^{-1}, available S=53.42 and 61.14 kg ha^{-1}, available Zn=0.31 and 0.39 mg.kg^{-1},and available B=.041 and 0.48 mg.kg^{-1}) respectively~~ and differed significantly~~. ~~It indicated that c~~Continuous cultivation of crops without adopting proper management practices leads toa decline in soil physical and chemical properties and proper management practices~~has~~haveto be adopted to sustain the properties of soil and crop productivity.

Keywords:chemical properties;physical properties;productivity;Rice–fallow; uncultivated~~; physical properties; chemical properties;productivity~~.

1. INTRODUCTION

Soil physical and chemical properties play a vital role in maintaining soil fertility that has been threatened by variousimproper agricultural practices resulting deterioration of soil health and productivity. Continuous cultivation of crops with improper management practices ~~on~~ in the longterm deteriorates soil's physical and chemical propertiesand declines crop yield [1]. A better understanding of the impact of continuous cultivation on soil properties is, therefore, essential for the improvement of soil quality and sustaining soil health and productivity. ~~Comparison~~ A comparison of soil under natural vegetation and adjoining cultivated soils has revealed that prolonged agricultural land use alters some soil properties, mostly those related to fertility [2]. Continuous cultivation with frequent tillage results in a rapid loss of organic matter through increased microbial activity [3]. Changes in soil properties due to continuous cultivation and management practices and their consequences on crop productivity is an important area of research for soils of Nalbari district, Assam.

Nalbari district is located in the central Western part of Assam and is one of the agriculturally important districts in the Lower Brahmaputra Valley Zone of Assam lies between 26^0 N Latitude and 91^0 E

Longitude with mean elevation 89 m above msl and comes under AESR 15.2 Q8B8 and 16.1C10A9. Though the district comprises 2.6% of the state's geographical area, it has 5.46% and 4.96% of the state's net and gross cropped area, respectively.The district of Nalbari is primarily agrarian, with about 80% of the population directly or indirectly dependent on agriculture and allied activities. Rice is the major crop and ~~rice~~ rice-based cropping systems are predominantly practiced by the farmers in the districtand the majority of the area comes under the rice-fallow system. Farmers cultivate rice crop with improper management practices that involves imbalance and injudicious use of nutrients, low farm input, and removal of residues from the field may lead to a decline in ~~the~~ soil organic carbonresulting decline in the productivity and sustainability of intensive rice based cropping system.

~~The present study was undertaken with an objective~~We carried out the current study to assess the impact of ~~long~~ long-term continuous cultivation of rice crops under ~~rice~~ the rice–fallow system on the physical and chemical properties of soils ~~comparing~~comparedwithadjacent uncultivated soils.

2. MATERIALS AND METHODS

Geo-referenced (N:26^{0}31.882' to 26^{0}18.224'and E:091^{0}30.536'to 091^{0}15.750') soil samples (0-15cm) fromrice-fallow cultivated soils were collected after the harvest of rice crops during the year 2014-16~~.~~ ~~For comparison,~~, as well as the soil samples from adjacent uncultivated sites were also collected. The representativeness and uniformity of the fields were taken into consideration while collecting the soil samples. The sampling is focused on the plough layer because; this is where most soil quality changes are expected to occur due to long-term land use and soil management practices. A~~l~~ltotal of 120 soil samples, 60 from cultivated rice-fallow and 60 from uncultivated soils, were collected covering 23 villages~~ of the district~~.At the time of the collection of soil samples, the crop history including management practices was recorded ~~from~~ bythe respective farmer.The soil samples were mixed uniformly, air dried in the shade, ~~and~~ sieved witha 2mm sieve, and ~~thereafter~~ kept in zipped poly pouches with proper labe~~l~~ling inside and outside the packet for analysis of physic~~al and~~ ochemical properties.

The physical properties like bulk density (BD), soil moisture content, soil texture, and water water-holding capacity of soils were determined for soil samples collected from cultivated rice-fallow as well as adjacent uncultivated soils. For the determination of bulk densityBD,undisturbed soil samples were collected from the field in natural conditions using a tube core sampler (5.2cm diameter and 9cm length) following the standard method [4]. The soil moisture content (MC) was determined using the gravimetric method for field moist soils by drying at 105^{0}C for 24 hours[4]. The texture of the soil samples were wasdetermined by the International Pipette Method [4]. Maximum water holding capacity (WHC)in percentage was determined by using Keen Rackzowski Box [4].The chemical properties such as soil pH, electrical conductivity, organic carbon (OC), **Cation Exchange Capacity (**CEC), available N, P, K, exchangeable Ca and &Mg, available S, and micronutrients such as available Zinc and boron were estimated following standard procedure [5].

Descriptive statistics was used for calculating the characteristics like mean, standard deviation (SD), minimum and&maximum of analyzed soil physical and chemical properties. To compare the means of eachindividual soil parameters between cultivated rice-fallow and uncultivated soils, the paired t t-test was carried out. SPSS software (version 16.0) was used for analysis of the entire dataset.

3. RESULTS AND DISSCUSSION

1. Crop History and soil management practices under rice-fallow system

High High-yielding rice variety Ranjit, has been grown for the past 10 years along with a few other varieties like *Bahadur* and *Mahsuri* and other traditional varieties of *Joha* and glutinous rice-*Bora*, *Baismuthi* under rain rain-fed conditions as mono mono-crop. Average The average yield of rice is recorded as (4.3 t.ha^{-1}) for HYV and 2.5 to 3.0 t ha^{-1} for traditional varieties. Use The use of organic manure was low and very irregular. Nutrient management conjoint with unscientific use of urea and SSP and a very little use of MOP leading to imbalanced nutrition. Tillage operation was carried out by power tiller and /or tractor. Farmers noticed the yield decline over the years. After the harvest of the rice, the field remains fallow.

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2. Soil physical properties

2.1. Soil texture

The soil textures of the selected sites of the rice-fallow system were recorded as sandy, loamy sand, sandy loam, loam, silt loam, and clay (Table 1). The textural distribution of soils varied widely depending upon the parent materials. This was in conformityconformed with the findings of extensive research works carried out on 107 soil series of Assam by Vadivelu*et al*. [6] including the soil series of Maroa, Tihu, and Nalbari of Nalbari district.

2.2. Bulk Density (BD)

The mean value of bulk density (BD) of the soils under the rice-fallow system was 1.40 Mg m^{-3} (±0.06) in cultivated sites compared to 1.34 Mg m^{-3} (±0.07) in adjacent uncultivated sites and differed significantly ($P<0.05$; Table 1). In the cultivated rice-fallow soils, 91.67% of soils showed a higher BD (>1.3 Mg m^{-3}) values and in the case of uncultivated soils, 36.67% was werefound to have higher BD. The higher BD in ricegrowing sites might be due to soil compaction arising from puddling operations during rice cultivation. Singh *et al*.[7] reported that excessive tillage and wet tillage (puddling) under the rice-wheat cropping system in general, resulted in gradual compaction of soils thus increases increasingthe BD. Both wetting wetting-drying and freezing-thawing cycles after tillage may also cause the bulk density to increase because of natural soil reconsolidation as reported by Assouline, [8] and Hu *et al*.[9]. The farm mechanization in tillage operation with continuous use of power tiller / /tractor and less incorporation of organic inputs in soils also contributed towards a higher value of BD.

2.3. Moisture Content (MC)

The mean soil moisture content (MC) of the cultivated rice-fallow soils [26.58% (±6.03)] after harvest of rice was non-significant (t test value 1.86) with uncultivated soils [27.01% (±5.09)] (Table 1). In bBoth cultivated and uncultivated soils showed a higher soil MC (>15%) in 98.33% and 100% of the selected sites, respectively. The higher soil moisture content might be due to the collection of soil samples immediately after the harvest of rice and characterized by the poorly drained characteristics of rice soils. Janssen *et al*.[10] reported that puddling over many years have hasthe potential to increase the plant's available water capacity in the puddled layer, but reduces the small coarse and meso-poreporous (50 to 0.2

µm) in the ~~plough~~ plowpan. In the case of uncultivated soil, it was attributed ~~due~~ to the higher ~~content of~~ organic matter which helps in the retention of water.

2.4. Water Holding Capacity (WHC)

The mean value of maximum ~~water holding capacity (~~WHC~~)~~ of cultivated rice-fallow~~[41.34% (±11.17)]~~ and uncultivated ~~[42.26% (±11.13)]~~ soils varied significantly (P<0.05; Table1) in which >80% of sites showed high WHC ~~(>30%)~~.The soil texture in the study sites varies from sandy loam, loam, silt loam, and clay and WHC is invariably controlled by soil texture.

Table: 1. Descriptive statistics of soil physical properties

Parameters	Cultivated			Uncultivated			Paired ~~t~~-test value
	Minimum	Maximum	Mean (±SD)	Minimum	Maximum	Mean (±SD)	
BD ($Mg.m^{-3}$)	1.25	1.6	1.40 (±0.06)	1.2	1.50	1.34(±0.07)	8.07*
MC (%)	13.60	34.80	26.58(±6.03)	15.40	35.30	27.01(±5.09)	1.86 *ns*
WHC (%)	19.80	63.10	41.34(±11.17)	21.20	63.70	42.26(±11.13)	6.80*

ns- non significant; * Significant at < 0.05 probability level.

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3. Soil chemical properties

3.1. Soil organic carbon (OC)

~~In the present investigation, the results illustrated that t~~The mean value of OC of cultivated rice-fallow~~[0.63% (±0.12)]~~ and uncultivated ~~[0.89% (±0.22)]~~ soilsvaried significantly (P<0.05; Table 2~~,~~ andFig1). Of the total cultivated rice-fallow soils only 15% soils were in the high range ~~(>0.75%)~~ of OC compared to 76.67% in uncultivated soils. In the present investigation, inappropriate soil management with low inputs, excessive tillage, and continuous ~~mono~~ mono-cropping primarily with rice for longer periods might have declined OC in cultivated rice soils compared to uncultivated soils (where ~~no~~ no-tillage operations were done). Maia *et al*[11] reported that conventional tillage caused a huge soil C loss by soil erosion and increasing soil OC decomposition rate while no-tillage increased soil OC pool in the soil by improving soil structure, reducing erosion, enhancing aggregate~~s~~stability, and providing physical protection.

3.2. Soil pH

~~In the investigation t~~The mean value of soil pH of cultivated rice-fallow ~~[5.51 (±0.51)]~~ and uncultivated ~~[5.93 (±0.68)]~~ soils remained non-significant (Table 2~~&~~andFig 1), in which 60~~%~~ and 83.33% of sites showed moderately ~~(4.5-6.0)~~ acidic in cultivated and uncultivated soils respectively. Earlier Reza *et al*.[12]reported that the cultivated soils were moderately acidic in Assam which ~~is in conformity~~conforms with the present findings.

3.3. Cation Exchange Capacity (CEC)

The low status ~~(<10 C mol (p+ kg^{-1})~~ of CEC in the cultivated rice-fallowand uncultivated soils ~~with the mean value of 6.72 C mol (p+) kg^{-1}(± 1.79) and 6.88 C mol (p+) kg^{-1}(± 1.83), respectively~~~~were~~as recorded(Table 2). Moral and Borah [13] also reported a lower value of CEC in the soils of LBVZ of Assam. Moreover, the results ~~were in conformity~~conformed with the findings of extensive research works carried out on the Nalbari soil series of Assam by Vadivelu*et al*.[6].

3.4. Electrical Conductivity (EC)

The electrical conductivity (EC) of the soils under rice cultivation and uncultivated soils ~~ranged between 0.01 and 0.08 dSm^{-1} and 0.01 and 0.06 dSm^{-1} with mean values of 0.03 dSm^{-1} (±0.01) and 0.03 dSm^{-1} (±0.01), respectively~~ exhibit~~ing~~edno significant difference ~~of the mean value of EC in between the cultivated and uncultivated soils~~ (Table 2). Karmakar [14]; Baruah *et al*.[15] reported that the EC of Assam soil is low (<1 dSm^{-1}) indicating no salinity problem in Assam soils and has no adverse effect on crop growth.

3.5. Soil available Nitrogen(N)

Conventional rice agroecosystems, especially in Assam, have been characterized by low input of chemical fertilizers and organic amendments, leading to a decline ~~of~~ inthe available nutrient status. The mean value of available N content of soils under rice cultivation ~~was 245.56 kg ha^{-1} (±86.07) compared to~~

the value of 418.37 kg ha^{-1} (± 85.45) inanduncultivated soils andvaried significantly (P<0.05; Table 2&andFig 1). In the cultivated rice soils 66.67% of the samples were low in available N content (<272 kg ha^{-1}) compared to 3.33% in uncultivated soils. N is highly mobile in the soil and has the highest probability, among the major nutrients, to be lost from the rice ecosystem through volatilization and leaching and especially in high high-rainfall areas like Assam. Higher organic matter content in uncultivated soilsis attributed to a higher level of available N in soils as compared to cultivated rice-fallow soils. Moreover, the use of low input of chemical fertilizers and organic amendments are isthe characteristic of the crops growing system of Assam, leading to a decline in available nutrients status. The cultivated soils in the subtropical region coupled with a preponderance of tillage practices and low external inputs are rarely sufficient in N as reported by Sanyal, *et al.* [16] which is in conformityconforms with the present study.

3.6. Soil available Phosphorus (P)

The mean value of available P content of the soils under rice cultivation was 31.27 kg ha^{-1}(±5.87) compared to the mean value of 42.62 kg ha^{-1}(±6 82)higher in uncultivated soils and varied significantly (P<0.05; Table 2& Fig 1). The soil under rice cultivation showed 1.67% of soils as low (<22.5 kg ha^{-1}), in available P and 98.33% in medium range,(22.5-56.0 kg ha^{-1}) and 3.33% were high (>56.0 kg ha^{-1}) in available P content. Since the soils of Nalbari district of Assam are acidic with low CEC, the low to medium range of available P in the soils under cultivated soils might be primarily due to the soil acidity that fixes the P into unavailable form as Al and/or Fe phosphate as well as low rate of application of phosphatic fertilizers as evidenced during soil samples collection. This was also reported that the average P fertility index is low to medium in Al and Fe- rich alluvial soils of Assam by Vadivelu *et al*.[6].

3.7. Soil available Potassium (K)

The estimation of available K was significantlywidely(P<0.05) differed across the location of the surveyed sites with a mean value of 120.98 kg ha^{-1} (±37.62) in cultivated rice-fallow soils as compared to the mean value of 145.90 kg ha^{-1} (±54.32) in uncultivated soils and exhibited significant differences (Table 2&andFig 1). In the cultivated rice soils 70.00% of the total samples were low (<136 kg ha^{-1}) in available K content, whereas 46.67% of the soils were found to be low (<136 kg ha^{-1}) in the case of uncultivated soils.

Under low input situation, research carried out by Talukdar and Das [17] inthe Brahmaputra Valley Zone of Assam, demonstrated varied K supplypower of soil including K deficiency.

3.8. Exchangeable Calcium (Ca)

Nutritional responses to Ca can occur with sensitive crops in acid soils with low CEC in high rainfall zones. The estimation of exchangeable Ca was widely differed across the locationsand the mean exchangeable Ca content in cultivated sites of rice-fallow was found to be of 5.35(±2.97 C mol (p+) kg^{-1} compared to the 5.93(±2.66) C mol (p+) kg^{-1} in uncultivated soils respectively (Table 2&andFig 1). The results illustrated that more than 50% of soils belonged to low [2-5 C mol (p+) kg^{-1}] to medium [5-10 C mol (p+) kg^{-1}] in exchangeable Ca content.Similar A similar status of exchangeable Ca was also observed in a pedological study carried out in Assam soilsby Dey and Sehgal,[18].

3.9. Exchangeable Magnesium (Mg)

The mean exchangeable Mg content in cultivated sites of rice-fallow was found to be of 2.13 (±1.02)C mol (p+) kg^{-1} compared to the 2.38 (±0.93) C mol (p+) kg^{-1}higher in uncultivated sites(Table 2&andFig 1). Theresults illustrated that more than 50% of soils under the rice-fallow systembelonged to the low [0.3-1 C mol (p+) kg^{-1}] to medium [1-3 C mol (p+) kg^{-1}]category in exchangeable Mg content. Extensive research works carried out by Vadivelu *et al*. [6] in the Nalbari soil series of Assam reported 3.81 C mol (p+) kg^{-1} Ca+Mg which conformedwere in conformity with the present investigation.

3.10. Soil available Sulphur (S)

In the present study, tThe mean available S content in cultivated sites of rice-fallow was found to be of 53.42(±23.22) kg ha^{-1} compared to the 61.14(±20.52) kg ha^{-1}higher in uncultivated sites(Table 2&andFig 1). The results illustrated that more than 60% of soils under the rice-fallow system belonged to the high (>44.8 kg ha^{-1}) category in available S content. In the present study, a high level of S is due to the continuous indiscriminate use of S S-containing fertilizers. Moreover, the higher content of S in uncultivated soils might be attributed due to the high level of organic matter as compared to cultivated rice-fallow soils.

3.11. Soil available Zinc (Zn)

The mean DTPA-Zn content in cultivated sites of the rice-fallow~~,~~was~~found to be of 0.31 (±0.12), mg kg^{-1} compared to the 0.39(±0.09), mg kg^{-1}~~higher in uncultivated sites (Table 2~~&~~andFig 1) and differed significantly (P<0.05). The results illustrated that more than 90% of soils under therice-fallow system ~~belonged to~~were deficient ~~(<0.6 mg kg^{-1})~~ in DTPA-Zn content. Similar findings of Zn deficiencies inthe soils of Assam ~~was~~ werealso observed by Bhuyan,*et al.*[19].

3.12. Soil available Boron (B)

The estimated mean available B content in cultivated sites of rice-fallow was higher ~~, found to be of 0.41(±0.15) mg kg^{-1} compared to the 0.48(±0.11), mg kg^{-1}~~in uncultivated sites (Table 2~~&~~andFig 1). The results illustrated that more than 70% of soils under the rice-fallow system belonged to the deficient ~~(<0.5 mg kg^{-1})~~ category in available B content. B deficiencies in Assam soils ~~was~~ werereported by Baruah *et al* [15]which were attributed ~~due~~ to the leaching of B during monsoon rain and less use of B in soil.

Table 2. Descriptive statistics of soil chemical properties

Soil chemical Parameters	Cultivated			Uncultivated			Paired t-test value
	Minimum	Maximum	Mean (±SD)	Minimum	Maximum	Mean (±SD)	
pH	4.6	7.0	5.51(±0.51)	5.0	7.4	5.93 (±0.67)	4.3*
EC (dSm^{-1})	0.01	0.08	0.03 (±0.01)	0.01	0.06	0.03 (±0.01)	0.38*ns*
CEC [C mol (p+) .kg^{-1}]	4.42	12.31	6.72 (±1.79)	4.51	12.41	6.88 (±1.83)	0.62*ns*
OC (%)	0.45	1.03	0.63 (±0.12)	0.54	1.70	0.89 (±0.22)	12.86*
N (kg.ha^{-1})	110.50	510.4	245.56 (±86.07)	255.4	545.0	418.37(±85.45)	13.71*
P (kg.ha^{-1})	20.57	47.57	31.27(±5.87)	30.5	57.2	42.62 (±6.82)	13.64*
K (kg.ha^{-1})	64.8	240.33	120.98 (±37.62)	10.0	300.10	145.90 (±54.32)	4.28*
Ca [C mol.(p+) kg^{-1}]	1.40	13.20	5.35 (±2.97)	1.7	13.2	5.93 (±2.66)	3.05*
Mg [C mol (p+) .kg^{-1}]	0.4	4.6	2.13 (±1.02)	0.80	5.0	2.38 (±0.93)	1.53*ns*
S (kg.ha^{-1})	3.67	112.9	53.42 (±23.22)	28.8	121.2	61.14 (±20.52)	6.49*
Zn (mg.kg^{-1})	0.13	0.86	0.31 (±0.12)	0.25	0.66	0.39 (±0.09)	7.63*
B (mg.kg^{-1})	0.11	0.89	0.41 (0.15)	0.30	0.78	0.48 (0.11)	4.68*

ns- non significant; * Significant at < 0.05 probability level.

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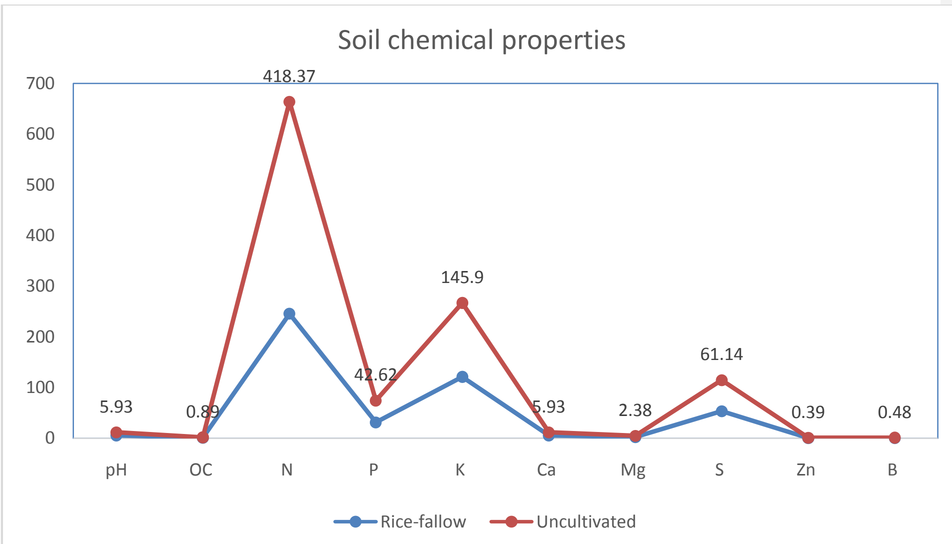

Fig. 1 Soil chemical properties under rice-fallow and uncultivated soils

4. CONCLUSION

The present investigation indicated that due to the continuous cultivation of rice crops, there was an increase ~~of~~ inthe BD value of soils as compared to the adjacent uncultivated soils. Similarly, the nutrient status of soil also showed a declining trend. ~~It can be concluded from the above study that c~~Continuous cultivation of rice crops~~on~~ inthe long term declines the soil's physical and chemical properties. Therefore, the cultivation of crops with proper soil management practices like balanced use of chemical fertilizers ~~on the basis of~~based on soil test values, use of organic manures, and inclusion of legume crops in crop sequenceetc has to be adopted for sustaining soil health and crop productivity.

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Comment [es1]: MUST BE UPDATED as only 38.9% (7 out of 18) of the listed references were published in the past five years. The percentage has to increase to at least 35-40%. Old and un-updated references negatively impact the study and indicate that the study is no longer a point of interest.

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