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A review of the evaluation of soil fertility status of Punjab state of India

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Abstract
Soil fertility is the most important factor for sustaining life. Around 70% of the Indian population depends on agriculture and related services for their livelihood. The increasing population needs to self-sustain in order to increase the Indian economy. Most of the farmers depend on high-yielding varieties and in order to provide nutrients for them they are using high fertilizers throughout the seasons. This leads to the deterioration of soil fertility and soil quality. In Punjab, the crops are grown throughout the year which is leading to desertification. To tackle the problem of land degradation it is required to test the soil for its nutrient capabilities and provide the optimum amount of fertilizers. Due to the overuse of fertilizers the soil and water are getting contaminated. The physico-chemical study is very much important for the optimization of fertilizer use efficiency. Different parameters are considered to assess the physico-chemical property of the soil like pH, electrical conductivity, texture, temperature, soil organic matter, available nitrogen, phosphorous, and potassium. This data can be used to provide the right amount of fertilizers to the plants.

Keywords: Macronutrients, soil fertility status, Physico-chemical properties

Introduction
Soil fertility is an important component of the good yield of crops. The soil's productive capacity depends on the complex yet little interactions between the physical, chemical, and biological properties of soil. Soil is a very important factor that provides necessary nutrients to plants. Soil organic matter (SOM), nitrogen (N), phosphorous (P), and potassium (K) are very critical components for growth, security, agroecological stability, and production of food. Soil organic matter which comprises 50% dry biomass serves as the basic foundation for the growth of plants (Marschner, 2012) [1]. Soil nitrogen is required for plant growth, differentiation, and senescence, which greatly impacts the growth, and remobilization of vegetative organs (Chen 2016) [2]. Likewise, soil phosphorous is an important factor for plant metabolic activities like ATP production, and energy transfer (Vance 2003) [3]. Soil potassium plays important role in controlling of plant's osmotic pressure and improving stomatal function (Ubach 2012) [4]. These are all the nutrients that indicate the soil quality and soil fertility. The status of fertility greatly depends on the presence, absence, and availability of these nutrients to the plants in a balanced quantity (Singh *et al*. 2019). High yield and high-quality of yield can be achieved by using scientific fertilization based on the soil nutrient status and deficiency of the nutrients (Chen 2018) [5]. To get a high yield, fertilization is done without proper knowledge which results in uneven distribution and low efficiency of fertilizers (Li 2019) [6]. The usage of excessive fertilizers is not only expensive but also produces several problems like environmental pollution, degradation of land, the toxicity of nutrients, etc (Lu 2015) [7]. Traditional methods of estimating soil fertility by direct field sampling and laboratory methods can estimate the soil nutrients precisely at the sample points (Jaber 2011) [8].

Soil fertility is the inherent capacity of soil to provide nutrients to specialized plants in adequate amounts when other factors such as moisture, temperature, light, and physical conditions are in favorable conditions. The physico-chemicals parameters of the soil greatly influence agricultural production and forest development (Kekane 2015) [9]. Soil test-based fertilizer recommendations are widely accepted by many developing countries which results in a higher level of productivity and better profits (Sultana *et al*. 2015) [10]. The usage of chemical fertilizers and pesticides makes the soil lose its fertility and get degraded. The application of the fertilizers should be based on the requirement of the crop and the ability of the soil to provide nutrients to the crops which can be found by the soil parameters like pH, Organic

matter, and available macro and micronutrients to the plants (Singh *et al*. 2019). To reduce soil degradation and loss of soil fertility it is essential to conduct the soil fertility status and evaluate the soil characteristics on different suitable scales and dimensions such as mapping of soil fertility, textural class, identification of different land use systems, to support suitable farm establishments which will increase the nutrient use efficiency (Siddique *et al*. 2015) [11]. There are a lot of constraints for the extensive soil testing throughout the country like lack of proper infrastructure, lack of skilled human resources, laboratories, and extension activities (Sultana *et al*. 2015) [10].

Location
The Punjab state of India covers an area of 50,376 sq. km between latitudes 29°32' North, and longitudes, 73°56' East.

Climate
It is bounded by the western Himalayas in the north and the Thar desert in the south and southwest west which mainly determines its climatic conditions. It receives south easterly currents of the summer monsoons coming over the Bay of Bengal. The mean annual rainfall varies from less than 300mm to about 1400 mm per annum. The mean annual temperature varies from 23.2 to 25.8 degrees Celsius. The summers are extremely hot and winters are extremely cool the mean monthly maximum temperatures are as high as 42 degrees Celsius, and the lowest monthly temperature average is about 4.7 degrees Celsius (Sehgal *et al*. 2015) [13].

Soils of Punjab
Based on the soil moisture regime the soils of Punjab come under the category of aridic which are found at the border of Haryana, and Rajasthan. These types of soils developed under Arid, and hot, semi-arid, and hot climatic conditions. They are calcareous and remain dry throughout the year. Another type of soil is ustic soil. these can be found mostly in the central part of Punjab which is developed under semi-arid and less hot conditions. They occur in a belt between the aridic soils and udic soils. these soils are generally without dispersed lime or secondary carbonates. The udic soils are found on the border of Himachal Pradesh which is sub-humid and less-hot foothills. The average rainfall is over 1000 mm. the natural vegetation mostly consists of shrubs and deciduous forests. The soils are generally reddish brown to olive green. These three are dominant moisture regimes. The soils of Punjab are mostly developed on alluvium on the indo-gangetic plain. The soils of Punjab are Aridisols which in turn are divided into three types the majority of soils are mostly Entisols, a fraction of the soils are Mollisols, and some paddy-growing soils come under a new order called Aquids (Sehgal *et al*. 2015) [13].

Soil PH
The soil pH is important in maintaining the optimum availability of nutrients. At very low pH phosphorous becomes unavailable to plants, the concentration of calcium in the soil reduces, and an increase in aluminum concentration leads to toxicity. At high pH, the availability of iron and other trace elements gets reduced as they become hydroxides and carbonates. The availability of micronutrients is more at low pH compared to high pH (Shakha *et al*. 2016) [12].

pH range	Soil
<7	Acidic
7	Neutral
>7	Alkaline

The soils in Punjab are mostly alkaline in nature. Most soil range between 7.0-8.2 (Makkar *et al*.). In the Tarn Taran district of Punjab, 92% of the soil comes under the normal range, 7.3% comes under the slightly higher pH level, and 0.9% with the highest pH (Bhat *et al*. 2017) [14]. In the sub-mountainous region of the Rupnagar district, the pH varied from 6.75-8.31 (Singh *et al*. 2021). In the area of Bathinda, the soil pH ranges from 8.27-8.52 with a mean value of 8.31 (Yadav *et al*. 2016) [22]. In the Shivaliks of Indian Punjab under different land use systems, the pH ranges from 6.9-9.4, 6.5-9.2, 8.2-9.3, and 8.6-9.4 for the agricultural, forest, aforestated, and non-arable lands respectively (Vashisht *et al*. 2020) [16]. In the sub-mountain region of Punjab, the pH decreases in the range of 6.4-6.9 which, is due to the leaching by the rainfed land use system (Maini *et al*. 2022) [17]. In the sugarcane-growing crops of Punjab, the soil pH ranges between 6.4-8.5 (Verma *et al*. 2016) [21]. In the orchards of Kinnow which are grown in Aridisols of Punjab, the pH ranges from 8.4 to 9.2 (Khokhar *et al*. 2012) [18]. In the soils of potato-growing pockets of the Hoshiarpur district, the pH value ranges from 5.0-8.2 with a mean value of 6.8 (Jatav *et al*. 2013) [27]. In the intensively cultivated soils of Punjab the pH range between 6.5-8.5 (Sharma *et al*. 2016) [19]. In the south western region of Punjab, the soil pH range between 7.68-7.98 (Mandal *et al*. 2018) [20]. In the soils of intensive rice-wheat and agroforestry-based cropping systems in the alluvial soils of Punjab, the mean pH in the agroforestry site is 8.00 and in the rice-wheat cropping site is 7.89 (Dhaliwal *et al*. 2020) [26]. In the apple-growing Punjab soils the pH ranges from 7.2-8.4 (Siddique *et al*. 2009) [28].

Electrical Conductivity
It is one of the important properties of the soil, it determines the total concentration of ions present in the soil. It is used to find soil quality. it is a quick, easy, and cheap method to determine the health of the soil. the soil ions determine the availability of salts and nutrients to the crops (Kekane 2015) [9]. The increase in the soil ions shows an increase in the salinity. The high salinity increases soil erosion and inhibits proper plant growth. The weathering, salts in native rocks, coastal areas with flooding, and fertilizers applications lead to an increase in electrical conductivity (Shakha *et al*. 2016) [12].

Table 1: Categorization of soil salinity on the basis of EC

EC (mmhos/cm or dS/m)	Soil
< 0.8	Normal
0.8-1.6	Harmful for salt-sensitive crops
1.6-2.5	Harmful for salt-tolerant crops
> 2.5	Harmful to all crops

The Punjab soil electrical conductivity is mostly less than 0.8 dS m-1 which comes under the normal level (Sharma *et al*. 2016) [19]. The electrical conductivity ranges between 0.21-0.31 dsm-1 (Makkar *et al*. 2018) [15]. In the soils of the Tarn Taran district of Punjab, the EC value ranged most of the soils with normal EC (99.3%) (Bhat *et al*. 2017) [14]. In the Bathinda region of Punjab, the soil EC ranges between 0.16-0.26 dsm^{-1} with an average of 0.19 dsm-1 (Yadav *et al*. 2016)

[22]. In the soils of the sub-mountain region of Punjab under rainfed land systems, the soil EC value ranges between 0.09-0.23 dsm-1 (Maini *et al*. 2022) [17]. In the Rupnagar district of Punjab the soil EC ranges between 0.28-0.89 dsm-1 (Singh *et al*. 2021). In the orchards of Kinnow which are grown in Aidisols of Punjab range from 0.06-0.32 dSm-1 in high-yielding orchards and 0.13-0.84 dsm-1 in low-yielding orchards (Khokhar *et al*. 2012) [18]. In the sugarcane-growing soils in Punjab, the EC value ranges between 0.04-0.35 dsm-1 (Verma *et al*. 2016) [21]. In intensively cultivated soils the EC value ranges between 0.31-0.98 dsm-1 (Sharma *et al*. 2016) [19]. In the soils of south-western Punjab, the EC value ranges between 0.32-0.46 dsm-1 (Mandal *et al*. 2018) [20]. The mean electrical conductivity of soils in rice-wheat cultivation sites and agroforestry sites are 0.11dsm-1 and 0.16 dsm-1 respectively (Dhaliwal *et al*. 2020) [26]. In the soils of apple growing region of Punjab, the electrical conductivity ranges from 0.12 dsm-1 to 2.00 dsm-1 (Siddique *et al*. 2009) [28].

Soil organic carbon

The most valuable property of the soil is organic matter. It binds the soil and prevents soil erosion to some extent. Organic matter is the storehouse of nutrients. It maintains the soil quality, property, fertility, and microbial population (Kekane 2015) [9]. The chief component of organic matter is organic carbon. The organic matter estimation is based on the soil's organic carbon. The product of 1.724 (Van Bemmlen factor) to the organic carbon value gives organic matter value. Which is based on the assumption that an average organic matter contains 58% organic carbon (Shakha *et al*. 2016) [12].

Table 2: Categorization of soil on the basis of available organic carbon

Organic carbon %	Rating
< 0.40	Low
0.40-0.75	Moderate
> 0.75	High

Most of the soils in Punjab are generally medium to low in organic carbon content. The percentage of organic carbon is decreasing in the soil due to intensive agriculture, over usage of chemical fertilizers, and stubble burning. The soils of Punjab's organic carbon content is less than 0.4% in the 32% area of the state, the soils with 0.4-0.75% are 57% of the total area of the state, and the soils greater than 0.75% represent 12% of the area of the state (Sharma *et al*. 2016) [19]. To tackle the loss of organic carbon organic manures, fertilizers should be used. In the Tarn Taran district of Punjab, the organic carbon percentage in the sample soils is 74.7% of soils are in the medium range, 15.3% in the low range, and 10% in the high range (Bhat *et al*. 2017) [14]. In the soils of Shivaliks of Punjab under different land use systems, the organic carbon percentage is 0.03-0.75, 0.03-0.45, 0.12-0.33, and 0.12-0.72 in agricultural, forest, aforestated, and non-arable lands respectively (Vashisht *et al*. 2020) [16]. In the soils of intensively cultivated soils of Punjab, the organic carbon percentage is less than 0.40% in 31.6% area of the state with a mean of 0.32%, between 0.40-0.75 comprises 56.6% area of the state with a mean of 0.55% and greater than 0.75% comprises in11.8% area of the state with mean 0.82 (Sharma *et al*. 2016) [19]. In the soils of south-western Punjab, the organic carbon was recorded as 8.91 g/kg of soil in horticultural land, 5.96 g/kg of soil in cropland, and 3.65 g/kg of soil in uncultivated soil (Mandal *et al*. 2018) [20]. In the major sugarcane-growing soils of Punjab, the organic carbon content ranges from 0.23-0.94% (Verma *et al*. 2016) [21]. In the soils of Bathinda, the organic carbon ranges from 3.2 to 8.7 g/kg with an average value of 4.9 g/kg (Yadav *et al*. 2016) [22]. In the soils of potato-growing pockets of Punjab the organic carbon ranges from 0.2-0.7% (Jatav *et al*. 2013) [27]. In the Shivaliks foothills of Punjab, the organic carbon content is around 5.36 g/kg in horticulture, 7.16 g/kg in farm forest, and 5.34 g/kg in cropland (Bhople *et al*. 2020) [23]. In the soil of the Rupnagar district, the organic carbon content varied from 2.70-8.00 g/kg with a mean of 5.50 g/kg (Singh *et al*. 2021). In the rice-wheat system, the organic carbon content ranges from 0.74-1.05% with a mean value of 0.87% (Mondal *et al*. 2019). The mean of organic carbon in soils of agroforestry and intensive rice-wheat cultivation sites are 0.27% and 0.24% (Dhaliwal *et al*. 2020) [26].

Available Nitrogen

The amount of nitrogen in the soil is linked with the amount of organic matter present in the soil as nitrogen makes up 5% of the organic matter approximately. The available forms of nitrogen in the soil are nitrates and ammonium forms. They are less than 1% of total soil nitrogen. Due to the continuous release of nitrogen from organic to inorganic forms the available nitrogen is more to the plants in the soil (Shakha *et al*. 2016) [12]. The atmosphere contains about 80% nitrogen gas. This nitrogen gets fixed by microorganisms. The nitrogen gets diffused into lakes and streams and gets fixed by blue-green algae into ammonia for algal use (Kekane 2015) [9].

Table 3: Categorization of soil on the basis of available nitrogen

Nitrogen (Kg/ha)	Rating
< 271	Low
271-543	Moderate
>543	High

The soils of Punjab are mostly low in available nitrogen. In the shivaliks soils of Punjab which are under different land use systems, the available nitrogen in the soil is 50.2-225.8 in agricultural land, 62.7-174.6 kg/ha in forest land, 75.3-175.6 kg/ha in aforestated land, and 112.9-263.4 kg/ha in non-arable land (Vashisht *et al*. 2020) [16]. The soil of the submontane region of Punjab contains 29.32-32.6 kg/ha of available nitrogen, the low value of nitrogen is maybe due to the leaching loss and low vegetation (Maini *et al*. 2022) [17]. The available nitrogen in the Kinnow orchards ranges from 120-202 kg/ha with a mean of 148.2 in the case of high-yielding orchards and 69-89 kg/ha with a mean of 80.89. in the case of low-yielding orchards in both the cases, the available nitrogen is very low (Khokhar *et al*. 2012) [18]. In the soils of southwestern Punjab, the highest available nitrogen content can be identified in horticultural land (100.35 kg/ha), then cropland (91.99 kg/ha), and lowest by uncultivated land (3.65 kg/ha) (Mandal *et al*. 2018) [20]. In the soils of Hoshiarpur district the potato growing soils, the available nitrogen percentage is ranged from 186.3-355.6 kg/ha with an average of 242.5 kg/ha (Jatav *et al*. 2013) [27]. The soils of major sugarcane-growing crops of Punjab contain available nitrogen of about 194.4-301.0 kg/ha) (Verma *et al*. 2016) [21]. In the soils of agroforestry and intensive rice-wheat cultivation sites the mean available nitrogen is 145.5 kg/ha and 106.60 kg/ha respectively (Dhaliwal *et al*. 2020) [26].

Available Phosphorous

It is one of the most important macronutrients to both plants and animals as it helps in the storage of energy. It also monitors the number of nutrient remains present in the plant nuclei (Kekane *et al*. 2015) [9]. The area under rice-wheat cultivation may decline the phosphorous reserves (Shakha *et al*. 2016) [12].

Table 4: Categorization of soil on the basis of available phosphorous

Phosphorous (Kg/ha)	Rating
12	Low
12-22	Moderate
>22	High

The Punjab soils are low to moderate in the case of phosphorous, around 36% area of the state has less than 12 kg/ha with an average of 5.1 kg/ha, and 18% area of the state has moderate available phosphorous levels ranging between 12-22 kg/ha with an average of 16.5 kg/ha, 19.6% area of the state has available content greater than 22 kg/ha with an average of 32.6 kg/ha (Sharma *et al*. 2016) [19]. In the soils of the Hoshiarpur district, the available phosphorous in the soils are at 20ppm which is very low and the application of phosphorous is necessary (Jatav *et al*. 2013) [27]. In the soils of major sugarcane growing regions the available phosphorous ranges between 10.4 to 39.2 kg/ha (Verma *et al*. 2016) [21]. In the soils of agroforestry and intensive rice-wheat cultivation sites, the mean available phosphorous is about 15.64 kg/ha and 12.65 kg/ha respectively (Dhaliwal *et al*. 2020) [26]. In the soils of apple growing region of Punjab the available phosphorous ranges from 4.800-32.6 kg/ha with a mean of 16.50 kg/ha (Siddique *et al*. 2009) [28]. In the Bathinda region the available phosphorous ranges between 17.5-21.5 kg/ha (Yadav *et al*. 2016) [22]. In the soils of Southwestern Punjab under different land use systems, the available phosphorous is 25.61 kg/ha in cropland, 25.03 kg/ha in horticulture land, and 13.03 kg/ha in uncultivated land (Mandal *et al*. 2018) [20]. In the Shivaliks foothills of Punjab under different land systems the available phosphorous is 32 k/ha in horticultural land, 30.4 kg/ha in farm forests, and cropland 31.4 kg/ha (Bhople *et al*. 2020) [23]. In the intensively cultivated soils of Punjab, the available phosphorous is low in 36.4% of the total area of the state with less than 12 kg/ha with a mean of 5.11 kg/ha, 17.8% area of the state is in the medium range in between 12-22 kg/ha with a mean of 16.47 kg/ha, 19.6% of the total area of the state is in high range in between 22-50 kg/ha with a mean of 32.58 kg/ha, and 26.2% of the total area of the state is in a very high range greater than 50% with a mean of 108.89 kg/ha (Mandal *et al*. 2018) [20]. In the soils of Kinnow orchards grown in aridisols of Punjab, the available phosphorous in high-yielding orchards range from 1.21-5.47 kg/ha with a mean of 2.69 kg/ha, in low-yielding orchards 1.21-1.46 kg/ha with a mean of 1.26 kg/ha (Khokhar *et al*. 2012) [18]. The district of Tarn Taran district of Punjab contains available phosphorous. The soils of Shivaliks of Punjab under different land use systems contain available phosphorous 3.0-41.8 kg/ha in agricultural land, 3-12.9 kg/ha in forest land, 2.3-4.6 in afforestation land, and 3.8-4.6 kg/ha in non-arable lands (Vashisht *et al*. 2020) [16].

Available Potassium

Potassium plays a major role in the plant's physiological processes. It is one of the macronutrients of plants. The opening and closing of the stomata. It plays a major role in plant metabolism, usage of lignin and cellulose for the formation of cellular structures, plant sugars production, and regulation of photosynthesis (Kekane 2015) [9]. Potassium also plays important in the synthesis of protein, chlorophyll, nitrogen transformation from nitrates, root absorption, translocation, and storage of carbohydrates. Available potassium includes the sum of water-soluble potassium and exchangeable potassium (Shakha *et al*. 2016) [12].

Table 5: Categorization of soil on the basis of available potassium

Potassium (Kg/ha)	Rating
<136	Low
136-333	Moderate
>333	High

The Punjab soils are rich in available potassium, about 92% of the total geographical area of the state the available potassium is greater than 113 kg/ha and the remaining 8% falls under the category of less than 113 kg/ha (Sharma *et al*. 2016) [19]. In the soils of agroforestry and intensive rice-wheat cultivation sites of Punjab the mean available potassium is about 221.04 kg/ha and 179.20 kg/ha respectively (Dhaliwal *et al*. 2020) [26]. In the soils of the Hoshiarpur district, the potato cultivation soils contain 79% of the soils that are low in potassium content, 19.2% in the medium range, and 2% in the high range (Jatav *et al*. 2013) [27]. In the soils of apple growing region of Punjab the available potassium ranges between 44.0-74.0 kg/ha with a mean of 58.30 kg/ha (Siddique *et al*. 2009) [28]. In the soils of Bathinda, the available potassium level ranges from 220-610 kg/ha with a mean value of 404 kg/ha (Yadav *et al*. 2016) [22]. In the major sugarcane-growing regions of Punjab, the available Potassium value ranges from 125.82-349.1 kg/ha (Verma *et al*. 2016) [21]. In the soils of south-western Punjab under different land use systems, the available potassium value is highest in cropland (225.87 kg/ha), followed by horticulture (220.27 kg/ha) and uncultivated land (13.03 kg/ha) (Mandal *et al*. 2018) [20]. In the intensively cultivated soils of Punjab, 7.7% of soils are low in available potassium less than 113 kg/ha with a mean of 81.9 kg/ha, 92.3% of soils are high in available potassium greater than 113 kg/ha with a mean of 636.3 kg/ha (Sharma *et al*. 2013) [19]. In the soils of kinnow orchards grown in the aridisol of Punjab, the available potassium in high-yielding orchards ranges between 103.2-121.4 kg/ha with a mean of 114.5 kg/ha, in low-yielding orchards the range varies between 51.0-103.2 kg/ha with a mean of 73.52 kg/ha (Khokhar *et al*. 2012) [18]. The soils under rainfed land use systems in submontane Punjab contain available potassium 10.3-21.3 kg/ha (Maini *et al*. 2022) [17]. The soils of different land use systems in the Shivaliiks of Punjab contain soil available potassium in the range of 42-300 kg/ha in agricultural land, 60-264 kg/ha in forest land, 75-189 kg/ha in afforestation land, and 36-96 kg/ha in non-arable land (Vashisht *et al*. 2020) [16]. Under different land use systems near the Shivaliks hills the available potassium in horticultural land is around 190 kg/ha, in the forest land is 186 kg/ha, and in the cropland is 199 kg/ha (Bhople *et al*. 2020) [23].

Conclusion

The soils in the Punjab region are neutral to alkaline. The increase in the soil pH may be due to the presence of CaCO3, or the low value of soil organic matter. Due to intensive

cultivation, the soil organic matter is depleted which results in an increase in pH the Ardisol soils of Punjab are alkaline with high pH. There is no big influence on the pH under different land use systems. In the sub-mountainous regions, the pH is acidic due to the leaching of salts. The electrical conductivity in the Punjab soils is at normal levels with less than 0.8 ds-m. in the soils of intensively cultivated lands the electrical conductivity is slightly elevated which is due to the usage of chemical fertilizers. In the soils of orchards, there is slightly elevated electrical conductivity, especially in the low-yielding orchards. In the soils of sub mountainous regions, the electrical conductivity is low. The soils of Punjab contain medium to low organic carbon percentages. Under the different land use systems the organic carbon is increasing in the sequence of non-arable land, agriculture, forest, and afforested lands this is due to the decomposition of organic matter in the soils. in southwestern Punjab, the horticultural land contains higher organic carbon than croplands. Due to stubble burning, and intensive cultivation, the organic carbon is getting depleted rapidly which leads to the loss of soil organic matter. The loss of organic matter decreases soil health. Due to the cultivation of high-yielding varieties throughout the year, the soil available nitrogen is reducing rapidly. In the soils of the submontane region, the available nitrogen is very low. The low availability of nitrogen in the orchards reduced the yield. The available nitrogen is low in agricultural land than in non-arable land. The soils of sugarcane cultivation lands have a higher amount of available nitrogen. Nitrogen is deficient in rice-wheat cultivation lands. The soils in Punjab are medium in available phosphorous content. In the soil in the intensive cultivation lands the available phosphorous is low. In the southwestern region of Punjab, the uncultivated lands are low in available phosphorous in the orchards of the aridisols region the available phosphorous is very low. The soils in forest lands, afforested lands, and non-arable lands are deficient in available phosphorous. The soils of Punjab are rich in available potassium. Due to the intensive cultivation, the potassium present in the mineral form changed into available forms. The available potassium is greater in agricultural land and lowest in non-arable lands. The soils under the rainfed land systems in sub-mountain regions are deficient in available potassium which is due to the runoff of rainwater, and leaching losses. It is important to maintain soil-available nutrients due to intensive cultivation the soil fertility is getting in worse condition.

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