THE EFFECT OF SOIL PHYSICAL AND CHEMICAL PROPERTIES ON THE INVASION OF WILD PLANTS TO FARMS IN TABUK REGION, KSA

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Abstract. Tabuk region is one of the largest regions in Saudi Arabia in terms of area. The most important challenges that can face agriculture in the region are weeds and environmental damage resulting from human activities. This study was prepared to know the relationship between the physical and chemical components of soil and the spread of weeds in the farms of the region. So field trips were conducted to the study area, then the area was divided into 4 sites, each site was divided into three parts, then divided into ten squares with an area of 1 m^2. The plant species were identified and named according to the flora books of Saudi Arabia. A total of 65 samples with an amount of 1 kg of soil were collected to a depth of one foot from more than one location. The correlation between the distribution of study sites on the coordination axes (CCA), and the first axis (AX1) was positive with the phosphorous element (r = 0.58). The second axis showed a positive correlation with chlorine (r = 0.46) and calcium (r = 0.42), and a negative correlation with each of the soil organic matter (r = -0.62), soil pH (r = -0.65). The third axis also showed a negative correlation with HCO_3 bicarbonate (r = -0.69) and EC (r = 0.42). The distribution of plants and their relationship to soil factors showed that there are ten plant species whose presence is associated with phosphorous. Multi-dimensional analysis trends for locations and plant species in the study area in Tabuk region using the TWA program TWINSPAN, Coordination (DCA: DECORANA) led to the division into four plant communities and their distribution was related to soil properties.
Keywords: *Tabuk region, plant diversity, plant distribution, weeds, soil variants*

Introduction

With an area of roughly 136000 km^2, Tabuk is one of Saudi Arabia's largest regions in terms of area, accounting for 6.9% of the country's total area (Saudi Geological Survey, 2017). It is characterized by geographical diversity, with coastal plains, mountainous areas, plateaus, and desert areas. It has a dry desert environment, with only 72.9 cm of annual rainfall (Hasanean and Almazroui, 2015).

The imbalance that affects agricultural production, as well as environmental harm caused by human activities, are two of the most significant issues that agriculture in the region may confront. The shortage of rains and the depletion of non-renewable groundwater have contributed to a rise in soil salinity and a decrease in groundwater levels, both of which have harmed palm tree productivity. The development of diseases and pests that harm farms, as well as the indiscriminate use of fertilizers and pesticides,

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are all factors that contribute to low plant yield. In many nations, weeds cause significant agricultural losses, with estimates ranging from 8% in industrialized countries to 25% in impoverished countries (Vissoh et al., 2004).

Arid and semi-arid regions are well recognized because of being susceptible to landscapes as well as other anthropogenic activities, which have recently increased as a result of fast urbanization and growth (Al-Mutairi, 2017). The nature of the relationship between plant and microbial diversity reveals the ecological drivers of community structure and function (Wardle et al., 2004; De Deyn and Van der Putten, 2005; Allan et al., 2013; Duhamel and Peay, 2015; Liu et al., 2021). Desertification, on the other hand, is a global issue that poses a serious environmental concern. It shows up as a loss of forest cover, the degradation of forests into bushes, grasslands, and even bare land, plant extinction, and the move toward single-community systems (Prăvălie et al., 2017). Once vegetation is abandoned, the land continues to deteriorate, causing unrest and discontinuity in soil and water, allowing soil to continue to develop and strengthen (Rayan et al., 2020). The above processes have such a negative impact on social and economic growth as well as the ecological structure of civilization (Jiang et al., 2014; Ma et al., 2020).

The soil in Tabuk area is deficient in mineral and organic materials, rendering large areas unsuitable for agriculture and necessitating treatment with fertilizer application and organic materials. Thistles are the most widely distributed plants in the region due to the drought that the soil suffers from (Al-Khudairi, 1991). Species of plants abundance was found to be related to magnesium and sodium, illustrating the importance of abiotic variables such as competitive rivalry in governing species diversity in this region (Al-Mutairi, 2017). In the Arabian Peninsula's deserts, there has been little investigation into the effects of soil variables on plant species compositions. The preponderance of the available study focused on the native vegetation, encompassing species of plants and life forms.

This research looked into the impact of the chemical and physical properties of soil on wild plant diversity in Tabuk region farms in Saudi Arabia.

Materials and methods

Study area

The present research was carried out on a variety of farms located in Tabuk region in the northwest corner of the Kingdom of Saudi Arabia, surrounded to the west by the Red Sea The region of Tabuk is situated 28.2453° N, 37.6387° E (*Figure 1*). The research area's sites and locations are depicted in *Table 1*.

Table 1. *Sites and coordinates of the study area and locations*

Site name	Coordinates
Tabouk City	28°33'41.4"N 36°26'26.4"E
Bir Bin Harmas	28°50'57.6"N 36°17'16.9"E
AL Nashifa	26°58'48.4"N 37°11'19.3"E
Tayma	27°45'59.7"N 38°05'56.9"E

The region is distinguished by a wide range of geological features (topography), which has resulted in the concentration of various minerals and natural components such as iron

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and granite in this area (Al-Balawi, 2015). Many morphological phenomena can be found in this area, including maritime, plain, mountains, valleys, and sand dunes. The percentage of areas covered by plateaus is 45.96%, mountains is 31.78% of the total area of the region. This topography provides an excellent indicator of the region's geological structure (*Figure 2*).

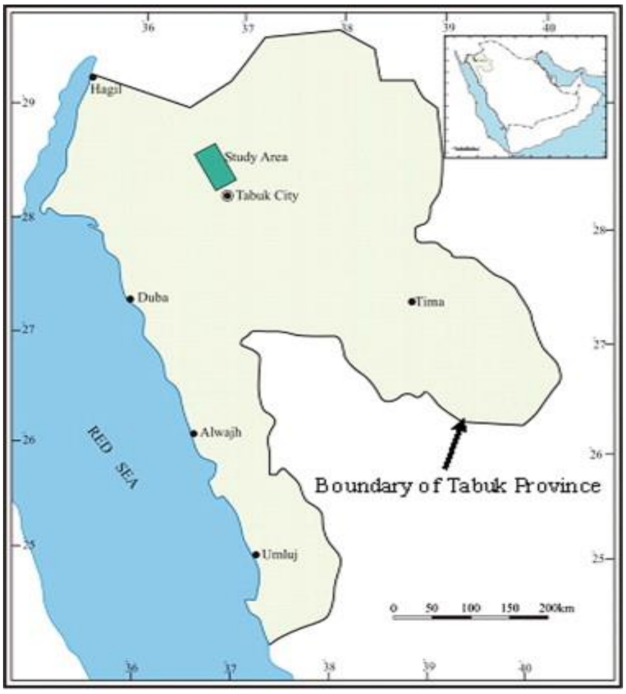

Figure 1. *Map of Tabuk region (Al-Harbi, 2010)*

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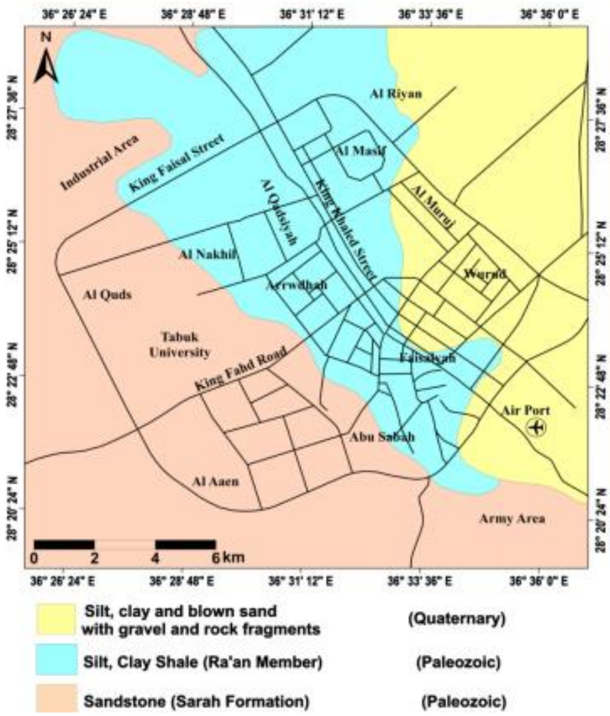

Figure 2. *Distribution of the soils in Tabuk city, KSA (Embaby et al., 2017)*

The climate of Tabuk region is one of arid desert climates. Temperatures in summer average are up to 40 degrees Celsius and drop in winter to an average of 7.6 degrees with annual rainfall, not more than 50 mm. *Figure 3* shows the climate change for Tabuk region between the years 2010-2019. The amount of precipitation varies from one place to another, as well as locally from one part to another.

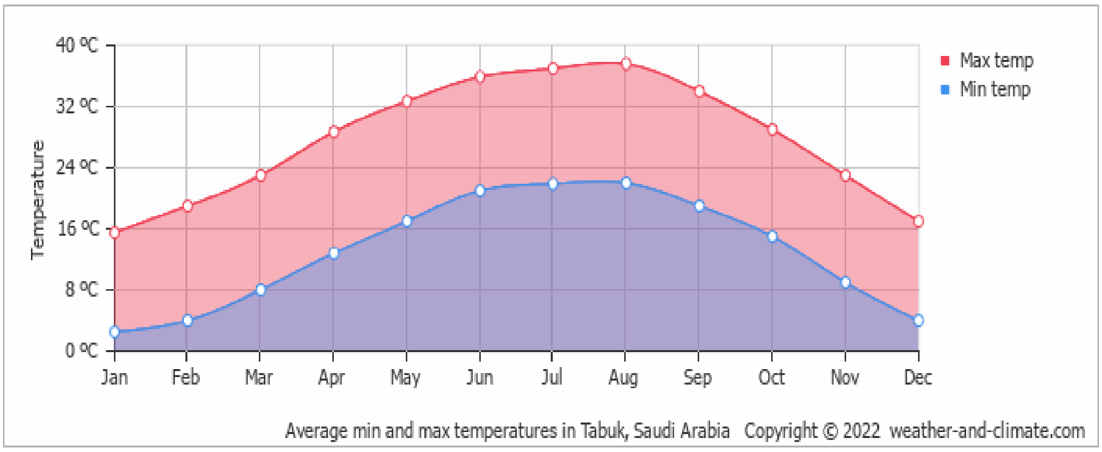

Figure 3. *shows the average Climate change for Tabuk region (by month) (https://weather-and-climate.com/average-monthly-Rainfall-Temperature-Sunshine, Tabuk, Saudi-Arabia)*

The soil of Tabuk region lacks mineral and organic materials, making large parts of it unsuitable for agriculture, and requires treatment with fertilizers and organic materials (Al-Khudairi, 1991).

Survey method

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1. Conducting intensive 6 field trips to study the farms included in the study during the months of March-April-May of the year 2020 and the months of February-March-April of the year 2021.
2. The sites that have vegetation cover from the weeds inside the farm were chosen for the implementation of the work through the survey by eye looking.
3. The area was divided into 4 sites, each site was divided into three sites, and each studied ten squares with an area of 1 m^2.
4. The plant species were identified and named according to the Flora Books of Saudi Arabia Flora (Collenette, 1985; Chaudhary and Al Jowaid, 1999; Chaudhary, 1999).
5. Using the Contrastive Division (TWA: TWIN SPAN) and coordination (DCA: DECORANA) program, the results were submitted to a multi-directional analysis of sites and plant species in the research area in the Tabuk region.

Soil collection

65 samples with an amount of 1 kg of soil were collected to a depth of one foot from more than one location, then mixed to form a composite sample from each farm, and kept in tightly closed plastic bags, and brought to the laboratory to complete the analysis of soil.

Chemical analysis of soil

Soil chemical analysis was carried out in the laboratories of Tabuk Agricultural Development Company (TADCO) and included soil pH, electrical conductivity Ec, organic matter, salts and a number of mineral elements in the soil solution.

Soil physical analysis

The dry soil was prepared pneumatically, and passed through a sieve with a diameter of 2 mm in order to prepare the 5:1 soil extract (1 g of soil to 5 mm of distilled water), where the pH meter was set using solutions known to have a pH value, and the pH values were recorded for each Soil solution using a pH meter (Fresenius et al., 1988).

Electrical conductivity (Ec)

The quantity of salts contained in the solution is represented by the electrical conductivity of the soil aqueous extract. This relationship follows Avogadro's rule because the electrical conductivity and osmotic pressure of salt solutions are dependent on the quantity of dissolved ions in a given volume of water. According to this law, the weights of a molecule in grams are the same for all compounds containing the same number of molecules.

This was recorded for soil solutions at the specified depth by using the electrical conductivity meter, and then the device was adjusted with a standard solution of potassium chloride KCl mos/cm µ 1411.8, which was prepared by dissolving 0.7456 g of potassium chloride salt in 500 mm distilled water, then One liter of distilled water is added to gradually complete the volume.

Through this, the value of the conductivity decismens/meter was calculated, and accordingly, the value of the dissolved salts can be calculated through the following:

1. Electrical conductivity E.C (dS/m x 10 = salt concentration in mEq/L
2. Electrical conductivity E.C (dS/m x 700 = salt concentration in parts per million

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3. Electrical conductivity E.C (dSm/m x 0.36 = concentration of salts at osmotic pressure

Determination of CO_2 and bicarbonate HCO_3

Carbonate (HCO_3) and bicarbonate are estimated by the titration of the soil solution after adding 2-3 points to it from 1% phenolphthalein index, and then it is titrated with a 0.01 standard solution of hydrochloric acid. Where the reading of the burette containing hydrochloric acid is taken (Vol. 1), when the color disappears after that, 2-4 points of 0.02 methyl orange are added and the titration continues with acid from the same burette, then the reading (Vol. 2) is taken (Black, 1985).

Determination of chlorides (Cl-)

To estimate the chlorides, 50 ml of soil solution was taken after adding 3-4 drops of potassium chromate index to it at a rate of 1% (Bardsley and Lancaster, 1960).

Determination of organic carbon

A sample was taken of 5 g of air-dried soil, and then 10 mm of potassium dichromate 1 N (1N) solution was added to it, after it was mixed well, 20 mm of concentrated sulfuric acid was added to it, and the soil was left for 20 minutes to ensure that oxidation occurs. Its contents were diluted with 20 mM distilled water, and then 10 mM phosphoric acid and 1 mM diphenylamine reagent were added. Then, titration was carried out using 0.5 N of the ammonium ferrous sulfate solution. Then a Planck titration was performed (Nelson and Sommers, 1960).

Determination of major elements (Sodium, potassium, calcium, magnesium and phosphorous)

The major elements (Sodium, potassium, calcium, magnesium and phosphorous) were estimated by atomic absorption spectrometry (FLAA) or plasma atomic emission spectroscopy (ICP-AES).

Data analysis

a) Plant coverage values for all plant species and for all sites were subjected to multi-directional analysis to classify sites into groups based on species cover values and using DECORANA, TWINSPAN, CANOCO.
b) The life forms of plant species were classified according to the Raunkiær system (Ellenberg, 1967; Naqinezhad and Zarezadeh, 2013)

Results

The relationship of the coordination axes of the DCA program with the prevailing environmental factors in Tabuk region

Table 2 illustrates the relationship between the distribution of study sites on the coordination axes (CCA), with the first axis (AX1) having a positive association with the phosphorous element P (r = 0.58). The second axis revealed a positive association with chlorine (r = 0.46) and calcium (r = 0.42), as well as a negative correlation with soil organic matter (r = -0.62) and soil pH (r = -0.65). HCO_3 bicarbonate (r = -0.69) and EC

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(r = 0.42) likewise had a negative connection on the third axis. *Figure 4* clearly shows that a suitable letter and number depict the study sites, and lines for which the length is directly proportionate to their significance symbolize the soil variables.

Table 2. *Correlation coefficient between environmental variables and coordination axes*

Variable	AX1	AX2	AX3	AX4
Org. Mat	-0.0462	-0.6208***	-0.2568	0.0120
sand	-0.1306	0.0664	0.3301	-0.2255
silt	-0.2073	-0.2460	-0.2481	0.0689
clay	0.2316	0.0211	-0.2639	0.1703
pH	-0.0619	-0.6508***	0.3451	0.2465
EC	-0.1484	0.4071	-0.4210*	-0.1401
Na	-0.2224	-0.0107	-0.2556	-0.2339
Ca	-0.0812	0.4156*	-0.1600	-0.0230
K	-0.1283	0.3007	0.1005	-0.4082
Mg	-0.1086	-0.1957	-0.1835	-0.2058
P	0.5809**	0.0650	-0.0514	-0.2853
CL	-0.1780	0.4559*	-0.4096	-0.0951
HCO_3	-0.1105	-0.2111	-0.6880***	-0.2129

Significant correlation $p \leq 0.05$* $p \leq 0.01$** $p \leq 0.001$***

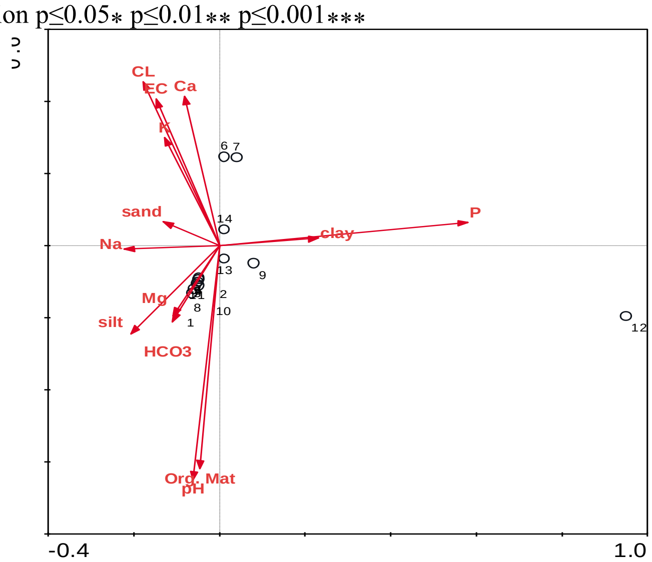

Figure 4. *The relationship of the distribution of the studied sites with soil properties (CCA ordination)*

Figure 5 depicts the distribution of plants and their relationship to soil properties on the DCA program's coordination axes, where we discover ten species of plants for whom the existence is affiliated with phosphorous, and they are: *Capsella bursa-pastoris, Cucumis prophetarum, Emex spinosa, Eruca sativa, Euphorbia peplus, Helminthotheca echioides, Hirschfeldia incana, Hoya caudata, Santolina chamaecyparissus*, and *Senecio glaucus*. While the plant species most closely related to the presence of chlorine and calcium were: *Asphodelus fistulosus, Calendula arvensis, Coreopsis lanceolata, Lepidium sativum, Matricaria discoidea, Plantago arenaria* and *Tetraneuris linearifolia*.

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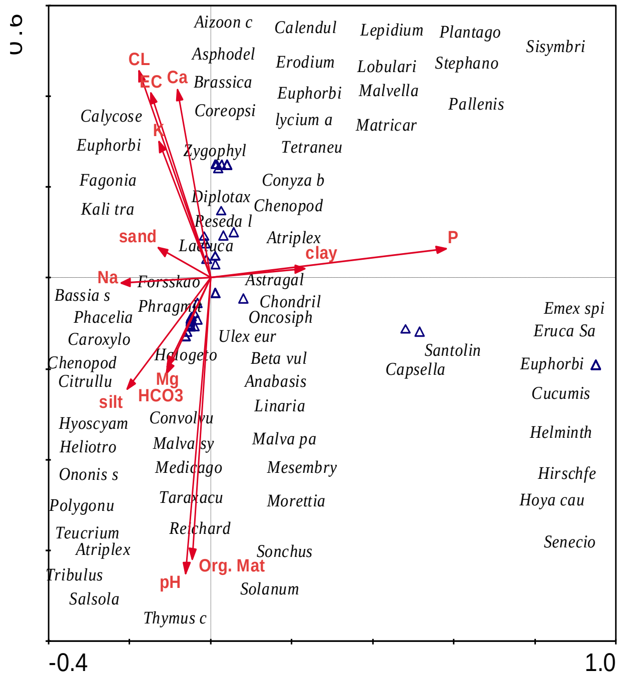

Figure 5. *The relationship of plant distribution with soil properties that have a significant effect on the direct coordination axes (CCA ordination)*

Soil properties of plant communities

Variation of plant species in Tabuk farms

The results recorded in *Table 3* show that the weed communities in the study area had a high diversity of plant species accompanied by a low prevalence. With Shannon's index (H′) to measure species variance scoring 1.840, 1.771, 1.804, and 1.901 for Tabouk City, Bir Bin Harmas, AL Nashifa, and Tayma, respectively, and the number of the most abundant species (N2) scoring 6, and 5, respectively, for AL Nashifa and Tabouk City farms. The Simpson index for determining domination was 0.21, 0.23, 20, and 19 for Tabouk City, Bir Bin Harmas, AL Nashifa, and Tayma, respectively.

Table 3. *Indicators of variation of plant species in different farms in Tabuk region*

Cultivation	Tabouk City	Bir Bin Harmas	AL Nashifa	Tayma
		Richness		
N0	9.429±3.359	10.571±3.552	10.124±3.443	9.625±3.602
		Diversity		
Simpson dominance	0.216±0.134	0.235±0.080	0.204±0.103	0.193±0.143
H' 'Shannon'	1.840±0.532	1.771±0.298	1.804±0.342	1.901±0.413
N1-equality abundant 'Hill'	6.996±2.994	6.099±1.807	7.006±3.104	6.884±2.483
N2-inverse Simpson 'Hill'	5.938±2.578	4.695±1.631	6.028±1.473	5.351±1.956
		Evenness		
E1	0.830±0.143	0.769±0.084	0.746±0.096	0.802±0.125
E5	0.808±0.095	0.711±0.103	0.754±0.135	0.733±0.054

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These relatively small numbers imply a decrease in domination and a rise in variety. The high values reported by the indexes (*Table 3*) measuring the degree of similarity across species (E1) and (E5), confirm this. This indicates that the significance values for the various species in the research area have converged, resulting in a high level of variety.

Table 4 indicates that the very first plant group (VG1), which itself is characterized by hyacinth and cress (*Sisymbrium irio - Lepidium sativum*), is by far the most diversified of the research area's natural vegetation. The abundance index of species (Richness = 17) demonstrates this. Shannon's indicator of taxonomic variation (H′ = 2.17), however, seemed to have the greatest value inside this vegetation types. The corresponding yield of Hill figures N1 and N2 were discovered inside this community because the most predominant species in the Sapphire and Cress community were seven species of plants; meanwhile the variety of species of the same vast quantities was approximately 9 species of plants. The findings also revealed that the third vegetation group (VG3), which also is dominated by ruminant plants (Zerbeeh) and blackberries (*Chenopodistem murale - Convolvulus arvensis*), is the least diverse community in the study area, with the fewest plant species recorded (Richness = 9).

The lowest value for species variance in the research area was calculated using the Dale Shannon score (H′ = 1.63). This also supports the minimum values seen in the indices assessing species equality (E1) and (E5) when compared to other plant communities in the study area (0.75 and 0.73, respectively). The maximum reduction of Hill numbers N1 and N2 were also found in this community, as being the most abundant species in the Al-Rumram and Blackberry community were four plant species, while the number of species with the same abundance was around five. Simpson's preeminence index recorded the maximum in the Ramram and Blackberry community, which is 0.27, confirming the minimum variance of species of plants in the third plant group (VG3).

Table 4. *Indications of species variation in plant groups resulting from multi-directional analysis of sites and plant species in the study area in Tabuk region*

Vegetation Group	VG1	VG2	VG3	VG4
Richness				
No.	17 ± 1.41	10.333 ± 3.06	8.875 ± 2.85	12.000 ± 0.00
Diversity				
Simpson dominance	0.175 ± 0.09	0.142 ± 0.02	0.269 ± 0.11	0.193 ± 0.00
H' 'Shannon'	2.172 ± 0.34	2.086 ± 0.17	1.626 ± 0.41	2.033 ± 0.00
N1-equality abundant 'Hill'	9.026 ± 3.00	8.131 ± 1.40	5.444 ± 2.02	7.638 ± 0.00
N2-inverse Simpson 'Hill'	6.698 ± 3.53	7.110 ± 0.95	4.247 ± 1.54	5.178 ± 0.00
Evenness				
E1	0.769± 0.14	0.912 ± 0.08	0.754 ± 0.09	0.818 ± 0.00
E5	0.672± 0.20	0.866 ± 0.13	0.726 ± 0.06	0.629 ± 0.00

Discussion

The majority of field data is used to calculate species variance. Scientists to measure the variance of species within plant communities have created many methods and guides. On the one hand, the proof is based on the number of species, while on the other, the

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consistency and frequency among those species. To measure species variance the farms, a number of the most prevalent markers were used.

The program Cross partitioning TWA: TWINSPAN, DCA: DECORANA format was used to do a multi-directional analysis of the subject area's locations and plant species for 14 sites and 69 species.

The research region's vegetation was categorized into four plants groups, and whose distribution was influenced by environmental conditions. The Mixed community of *Sisymbrium irio* and *Lepidium sativum*, as well as a diversity of species of plants, made comprised the first group. In comparison to other communities in the research region, bonariensis in this community with its constituent clay soil was the most diversified, according to a study (Rollin et al., 2019). The second society was symbolised by the *Lactuca serriola* plant, and a number of associated species of plants, along with the *Fagonia laevis* plant by 66.7 percent, and its dispersion was affiliated with the sandy soil that constituted this community, which is consistent with the study of Beier (2005).

The third society, composed of *Chenopodistem murale* and *Convolvulus arvensis*, as well as a series of interconnected species of plants with varying prevalence estimates, is the least diversified in the study area. The occurrence of *Chenopodistem murale* was found to correlate with the clay soil that constituted this community, and it was inversely correlated with bicarbonate (HCO_3) (r = -0.69) and EC (r = 0.42). This goes along with the study of Haroun et al. (2015) *Chenopodistem murale* was discovered to grow in clay soil and was positively associated with electrical conductivity, total soluble salts, sodium, and sulfate, whereas it was negatively associated with electrical conductivity, total soluble salts, sodium, and sulfate.

The allocation of plants and their correlation to soil characteristics is completely obvious on the DCA program's coordination axes, where we discover ten species of plants whose existence is affiliated with the element phosphorous, which is not exactly a surprise. It is usually recognized that it is a very basic nutrient in plant nutrition, and has been established in a study that it plays an important role in the restoration of species composition from heavy metal-contaminated soil (Attia-Ismail, 2016). Calcium and chlorine have such a significant role in plant nutrition, and their availability has been connected to the proliferation of several different species of plants.

Conclusion

Using the TWA software TWINSPAN, Coordination (DCA: DECORANA), multi-dimensional analysis patterns for locations and plant species in the study area in Tabuk region led to the classification into four plant communities, and their distribution was related to soil properties according to the findings. As can be seen, some plant communities have high plant diversity while others have low plant diversity.

There is a direct connection between the dissemination of plant communities in the study locations and their chemical nutrient content, as well as soil physics, electrical conductivity, and soil quality, whether sandy, loamy, or clayey. It is suggested that more specialized studies be conducted to manage weeds to reduce their impact on field crops.

Declaration of Competing Interests. The author declares no conflict of interests.

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