Journal of Himalayan Earth Sciences Volume 57, No. 2, 2024 pp. 62-73

Evaluation of High Value Medicinal Plants Used as Stop Wash Barriers to Intercept Runoff in Eroded Lands of Fateh Jang, Pakistan

Obaid-ur-Rehman[2], RahinaKausar[1*], MuhammadRashid[3], Muhammad Imran Akram[4], Ayesha Malik[1], Muhammad Usman Mohsin[1], Asia Munir[1], Kouser Majeed Malik[3]and Saftain Ullah Khan[5]

[1] Soil and Water Conservation Research Station, Fateh Jang, Pakistan
[2] Soil and Water Conservation Research Institute, Chakwal, Pakistan
[3]. Soil and Water Testing Laboratory, Rawalpindi
[4].Regional Agricultural Research Institute, Bahawalpur
[5].Soil and Water Testing Laboratory, Attock
**Corresponding author's email: rahinaawn@ gmail.com*
Submitted date: 27/03/2024 Accepted date: 15/05/2024 Published online: 30/11/2024

Abstract

Rainfed soils are more vulnerable to erosion as compared to other areas. The best strategy to conserve these soils from degradation is to provide soil cover e.g., agronomic cover which plays a vital role to intercept raindrop in situ which ultimately minimizes the rate of runoff. Farmers in rainfed areas mostly cultivate forages and fodder crops which act as soil cover and source of feed for their livestock without significant economic return. It has been anticipated that use of medicinal plants is increasing day by day for the cure of diseases. Therefore, considering above objective research was planned to introduce high value medicinal plants which improve soil health and quality. The research was conducted at Soil and Water Conservation Research Station, Fateh Jang during 2019-2023. The selected plant species included were *Steviarebaudiana, Aloe barbadense miller, Menthapeperita, Melissa officinalis, Mentharoyleana, Salvia rosmarinus, Origanumvulgare, Murrayakoenigii, Ocimumtenuiflorum.* In addition, in Rabi season *Foeniculumvulgare, Lepidiumsativum, Trigonellafoenum-graecum, Nigella sativa* and *Carumcopticum* showed best performance. The outcomes of the study revealed that these plants species effectively, restored the soil health and improve the soil physiochemical characteristics. So, cultivation of these plants as a cover crop will ultimately uplift socio-economic condition of farmers in respect of more economic return from the same piece of land by adopting innovative technology of medicinal plant cultivation.

Keywords: Medicinal plants, Runoff, Stop wash barriers, Eroded lands, Fateh Jang.

1. Introduction

Pakistan is located between 23 degrees to 36 degrees N latitude and 60 degrees to 75 degrees E longitude with varying altitude from 0 to 8611m having an area of 80,943 km2 with diversity and variable climatic zones. Ali and Qaiser (1986) reported that among 6000 species of higher plants only 10 % are used medicinally. Herbal medicines source in the worldwide is medicinal plants (Chen et al., 2016). Anthropological actions caused severe environmental problems especially land degradation worldwide and unable to achieve higher agricultural production (Khadija et al., 2021). Medicinal plants which are native to a specific area are well-adapted to the local environment. Therefore, conserving these plants and their habitats, in addition to soil conservation efforts also contribute to biodiversity in the region.

In arid and semi-arid regions of the world soil degradation resulted in soil erosion and loss of soil structure that reduces microbial activities. In the same way runoff increases and soil infiltration rate decreases resulting in crop failure (Jones and Rowe, 2017). Cultivation of deep root plants play vital role in soil conservation by Deep Root Systems. Many medicinal plants have deep root systems that help in soil stabilization. These roots penetrate deep into the soil, holding it together and preventing erosion, especially in areas prone to landslides and soil erosion. These plants also have the ability to bind soil particles together, reducing soil erosion caused by wind and water by creating dense network of roots and rhizomes that act as a natural barrier against soil movement.

Medicinal plants also contribute to improving soil structure by adding organic matter to the soil as study conducted by (Asfaw, 2022) through their leaf litter and root exudates. This enhances soil fertility, water retention, and nutrient availability, which are essential for sustainable agriculture in the region. Deep root systems of medicinal plants help in preventing nutrient leaching by holding nutrients in the soil and making them available to other plants. This nutrient retention contributes to maintaining soil fertility and productivity in the Potwar region.

Overall, medicinal plants play a multifaceted role in soil conservation as studies showed by Abidi et al. (2019) and Delijouei et al. (2023) in the Potwar region. Potwar region has undulated topography and medicinal plants play a crucial role in slope stabilization. Jia et al. (2012) Their deep roots anchor the soil and prevent it from sliding downhill during heavy rainfall or strong winds, thus reducing the risk of landslides and soil erosion.

Many medicinal plants are cultivated using traditional farming practices such as agroforestry and mixed cropping. These practices promote biodiversity, improve soil structure, and enhance ecosystem resilience, thereby supporting long-term soil conservation efforts in the Potwar region. The conservation and sustainable management of medicinal plants often involve local communities who have traditional knowledge about their cultivation and use. By engaging local communities in conservation efforts, there is greater awareness and participation in soil conservation activities, leading to more effective and sustainable outcomes.

By recognizing the value of these plants and integrating them into land management strategies, it is possible to enhance soil health, preserve natural resources, and promote sustainable development in the region. Jafari et al. (2018) stated that soil structure become poor due to lack of organic matter and poor soil covers. Medicinal plant business will flourish to 5 trillion US dollars by the year 2050 (Shinwari and Qaisar, 2011). Inappropriate soil management practices and mining activities resulted in degradation of lands across the globe due to human activities (Keesstra et al., 2016). So, keeping in view of the above objectives study was planned regarding evaluation of medicinal plants in the Potwar region contribute for soil conservation through a combination of erosion control, water conservation, slope stabilization, carbon sequestration, traditional farming practices, and community involvement.

Material and Methods

The medicinal plants for experiment were selected prior to ethno-medicinal data collection on the basis of survey in district Attock by conducting regular visits in the month of May and June 2020 to select suitable sites and data collected about farmers well aware about medicinal plants were also recorded. The medicinal plants wereselected for experiment that was well adapted to local environmental conditions in Attock District (Table 1). The selected medicinal plant species were tested in the research area of Soil and Water Conservation Research Station, Fateh Jang. The data regarding adaptability % (Table 1), plant height (Table 4),yield (Table 5) and plant periphery (Table 6) was recorded accordingly. The well adaptable medicinal plants were tested in the farmer field and benefit cost analysis was done. Soil chemical and physical properties were also taken.

Perennial Medicinal Plants

The medicinal plant species i.e. *Stevia rebaudiana, Aloe barbadense miller, Menthapeperita, Melissa officinalis, Mentharoyleana, Salvia rosmarinus, Origanumvulgare, Murrayakoenigii, Ocimumtenuiflorum* were propagated in the month of August at Research Area of Soil and Water Conservation Research Station, Fateh Jang having much more economic and medicinal values. At the time of plantation initially plants were irrigated till the establishment.Ten plants in each row were planted and replicated thrice for data collection.

Rabi Medicinal Plants

In the Month of mid-October *Ocimum tenuiflorum, Foeniculum vulgare, Lepidium* *sativum, Trigonella foenum-graecum, Nigella sativa* and *Carum copticum* were grown. The experimental plots were irrigated before sowing to obtain field capacity at appropriate moisture level for maximum germination of seed and seed were sown on both sides of beds by chocking method. The bed of size 8m x10m=80m^2 was used. The seeds of all medicinal plants were collected from registered botanical shop of in the local market. Frequent irrigations were applied during drought period for better growthand development of plants. The additional irrigation was applied at heading stage for healthy seed development. The weeds were uprooted manually.

The data regarding plant periphery (cm), plant height (cm) was recorded with the help of measuring tape at time of maturity and grain yield (kg ha^{-1}) was recorded at harvesting of medicinal plants. Ten plants in each row were planted and replicated thrice for data collection. The data were analyzed by using Fisher analysis of variancetechnique difference among medicinal plants means were compared by using LSD test at $p<0.05$.

Table 1: The medicinal plants species selected for experiment at Soil and Water Conservation Research Station, Fateh Jang, Distt. Attock

Sr. No.	Common and Scientific Name	Parts used	Medicinal use	Adaptability status
1.	Stevia (Stevia rebaudiana)	Leaves	Natural sweetner	Adaptable
2.	Alovera (*Aloe barbadense miller*)	Gel	Antioxidant	Adaptable
3.	White Mint (*Mentha peperita*)	Leaves	Digestion issues	Adaptable
4.	Lemon Balm (*Melissa officinalis*)	Leaves	Anxiety, Insomnia	Adaptable
5.	Mentha(*Mentha royleana)*	Leaves	Cure sour throat	Adaptable
6.	Rose Mary (*Salvia rosmarinus*	Leaves	Epilepsy, Hysteria	Adaptable
7.	Oregano (*Origanumvulgare*)	Leaves	Wound healing, Parasitic infections	Adaptable
8.	Karri Patta (*Murrayakoenigii*)	Leaves	Regulate blood sugar, Aid healthy digestion	Adaptable
9.	Tulsi(*Ocimumtenuiflorum*)	Leaves	Inflammatory, Antioxidant	Adaptable
10.	Fennel (*Foeniculumvulgare*)	Seed	Digestive, Endocrine issues	Adaptable
11.	Haloon (*Lepidiumsativum)*	Seed	Source of fiber, Asthma	Adaptable
12.	Methry (*Trigonellafoenum-graecum*)	Leaves	Lower blood sugar	Adaptable
13.	Kalonji (*Nigella sativa*)	Seed	Boost memory, Control blood pressure	Adaptable
14.	Ajwain (*Carumcopticum*)	Seed	Antimicrobial, Lower inflammation	Adaptable

Source: Certified Nurseries of Islamabad & herbarium of NARC

Soil Parameters

The basic soil analysis before conducting experiment indicated in Table 2.

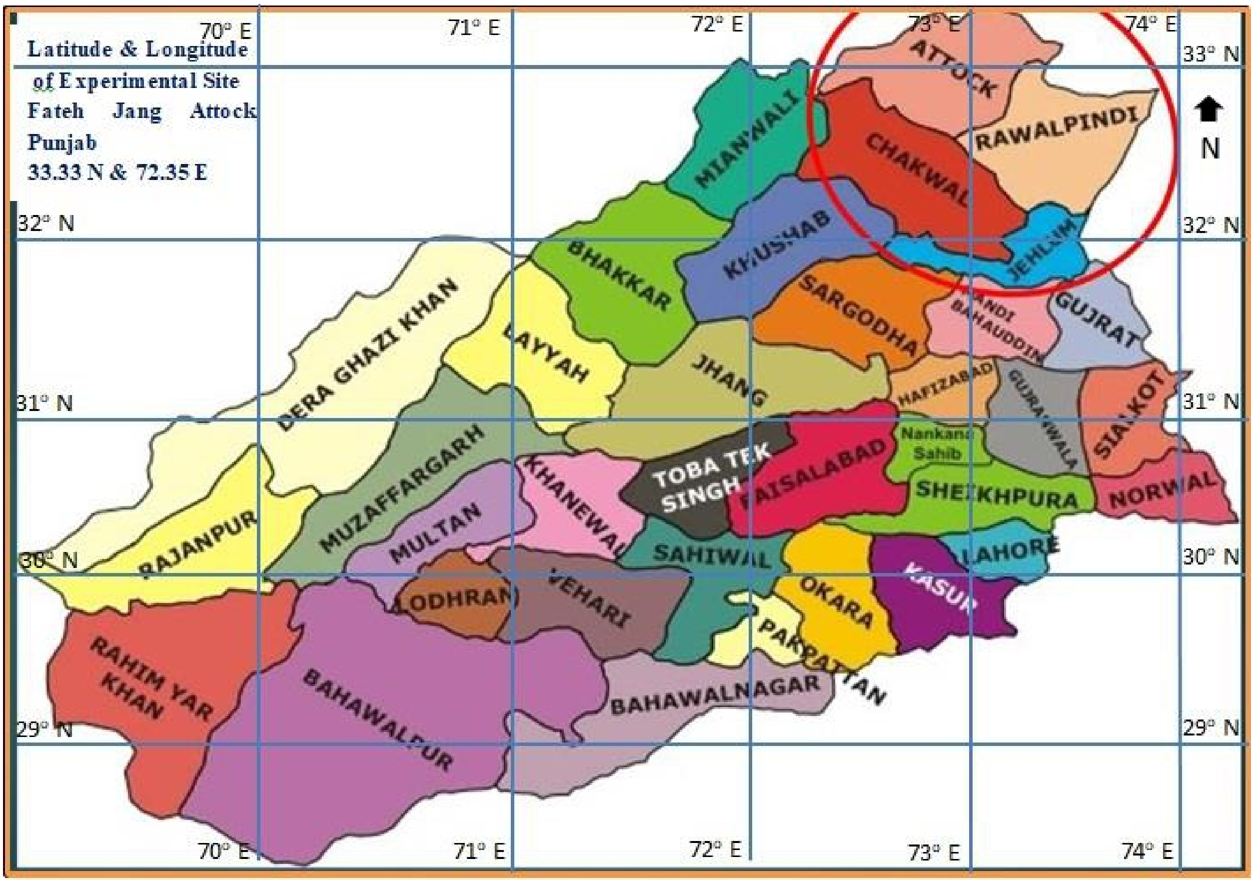

Fig. 1. The location map of the experimental site, Fateh Jang, Attock, Punjab.

Table 2: Physico-Chemical Characteristics of Experimental Site

pH	**ECe** (dS m^{-1})	**O.M.** (%)	**P_2O_5** (mg kg^{-1})	**K_2O** (mg kg^{-1})	**Saturation** (%)	**Texture**
7.70	0.0.95	0.66	3.4	65.0	22.0	Silt Loam

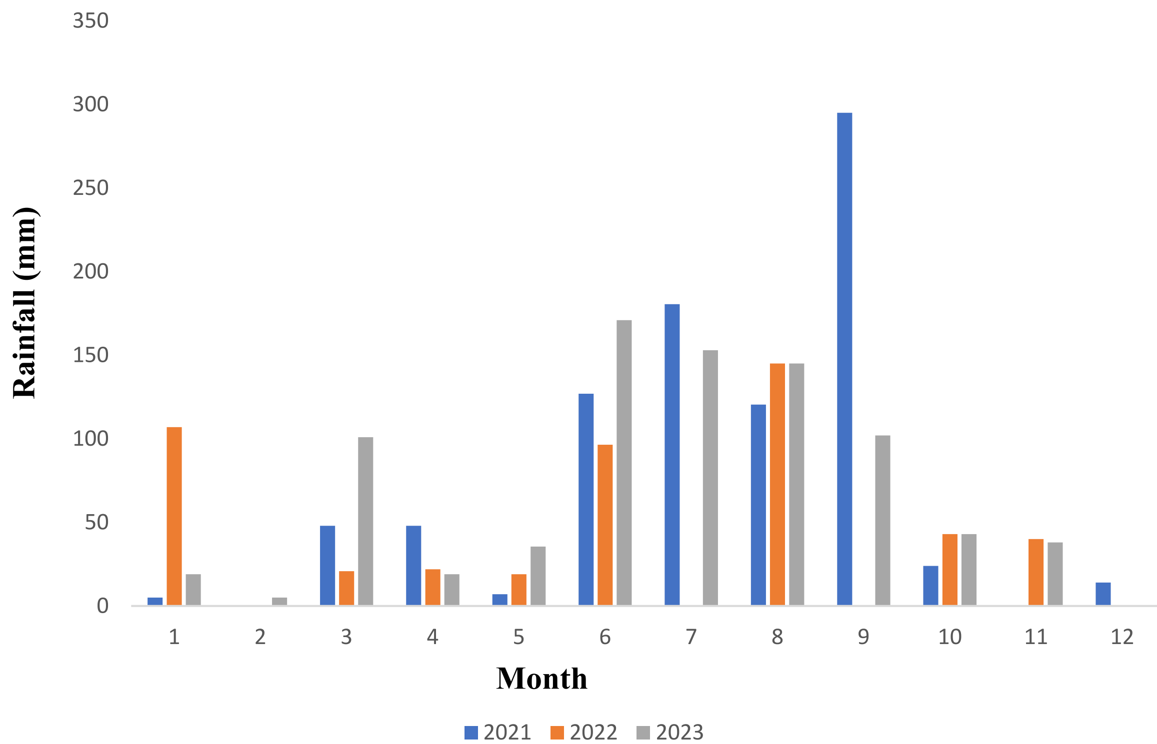

Fig. 2. Rainfall (mm) was recorded at experimental site from 2021-2023.

Rainfall and Temperature

The results in fig. 2 indicated that maximum rainfall (295mm) occurred during the year 2021 while it varied during the months of June to July that may affect the crop growth and development in arid area. The temperature data showed in fig. 3 indicated that maximum temperature observed in the months of May to June that are dry months and affect the growth and development of crop. With the rise of temperature in the arid area evapotranspiration increases that may interrupt the growth of medicinal plants resulted in less growth rate and low biomass yield.

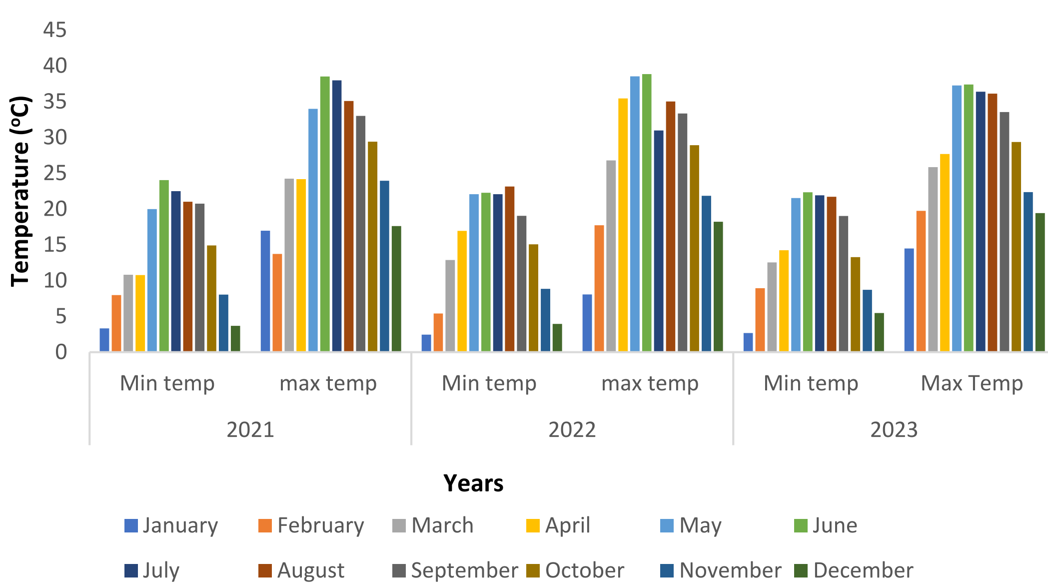

Fig. 3. Temperature recorded at experimental site.

Results And Discussion

A. Crop Parameters

I. Plant height (cm)

Data concerning plant height (cm) of various plant species for the experiment duration presented in (Table 3) exhibited that highest plant height (100 cm) was recorded by *Stevia rebaudiana* in 2021 while lowest plant height (23 cm) was obtained by *Mentha royleana.* Maximum Plant height (120 cm) during 2022 was recorded by *LepidiumsativumL* while minimum plant height (35 cm) was recorded by *Mentha royleana* and *Nigella sativa* was statistically similar with *Carumcopticum* (55cm). While discussing about the year 2023 plant height (160 cm) was recorded by *Murrayakoenigii* while lowest plant height (30 cm) was recorded by *Melissa officinalis* and *Melissa officinalis* was statistically similar with *Mentha royleana.* Due to variation in rainfall growth and development of plant affected in various plat species every year that resulted in variation in plant height. Generally, throughout the experiment duration *Murrayakoenigii* accomplished more plant height incomparison to other medicinal species plants because of its upright growth function. These results are in accordance with Jain et al. (2012).

Table3: Plant height (cm) of selected plant species.

	Varieties	**2021**	**2022**	**2023**
1	Stevia (*Stevia rebaudiana*)	100 A	88 B	85 C
2	Alovera (*Aloe barbadense miller*)	45G	60 F	40 H
3	White Mint (*Menthapiperita*)	45 G	70 D	90 B
4	Lemon Balm (*Melissa officinalis*)	63 E	45 G	30 J
5	Mentha (*Mentha royleana*)	23 K	35 I	28 J
6	Rose Mary (*Salvia rosmarinus*)	33 J	45 I	47 I
7	Oregano (*Origanumvulgare*)	50 H	75 E	70 F
8	Karri Patta (*Murrayakoenigii*)	75 E	110 B	160 A
9	Tulsi (*Ocimumtenuiflorum*)	45 I	60 G	80 D
10	Fennel (*Foeniculumvulgare*)	90 B	110 B	75 E
11	Haloon (*Lepidiumsativum*)	70 F	120 A	95 B
12	Methry (*Trigonellafoenum-graecum*)	70 F	45 I	60 G
13	Kalonji (*Nigella sativa*)	30 J	55 E	45 F
14	Ajwain (*Carumcopticum*)	30 J	55 E	45 F

II. Plant periphery

Data regarding plant periphery (cm) shown in (Table 4) of different medicinal plant species showed that maximum periphery (185 cm) obtained in perineal plant of *Salvia rosmarinus* while minimum periphery recorded in rabi plant of *Trigonellafoenum-graecum* during 2021. During the year 2022 and 2023 *Murrayakoenigii* obtained highest plant periphery i.e. 250 & 260 cm while lowest plant periphery 13 & 9cm recorded in *Carumcopticum.* Plant periphery is important to provide maximum cover to eroded soil for conservation purpose. Data concerning plant periphery (cm) of various plantsthroughout the experiment period presented in (Table 4) revealed that higher plant periphery (185 cm) was recorded by *Salvia rosmarinusin* the year 2021 and it was statistically alike with Murrayakoenigii (130 cm) During the year 2022 highest plant periphery (250 cm) was achieved by *Murrayakoenigii* & *Salvia rosmarinus* (230 cm) it was statistically differ) while minimum plant periphery was obtained by (9 cm) and was statistically similar with *Trigonellafoenum-graecum* while in year 2023 highest periphery (260cm) was obtained by *Murrayakoenigii* and was statistically different with other plants as *Mentha royleana* (160cm) while minimum plant periphery (8cm) was obtained by *Lepidiumsativum* and was statistically similar with other plants i.e. *Foeniculumvulgare* (20cm) and *(Trigonellafoenum-graecum),* Nigella sativa (15 cm), *Carumcopticum* (13 cm) that may be

Table 4. Plant periphery (cm) of selected medicinal plant species.

Sr. no.	Varieties	20-21	21-22	22-23
1	Stevia (*Stevia rebaudiana*)	70 F	77 F	80 HI
2	Alovera (*Aloe barbadense miller*)	100 D	87 F	90 C
3	White Mint (*Menthapiperita*)	90 DE	83 F	85 C
4	Lemon Balm (*Melissa officinalis*)	130 C	127 D	140 B
5	Mentha (*Mentha royleana*)	143 B	151 C	160 B
6	Rose Mary (*Salvia rosmarinus*)	185 A	230 B	110 B
7	Oregano (*Origanumvulgare*)	102 D	73 G	85 C
8	Karri Patta (*Murrayakoenigii*)	130 C	250 A	260 A
9	Tulsi (*Ocimumtenuiflorum*)	83 E	95 E	75 C
10	Fennel (*Foeniculumvulgare*)	15 G	15 H	20 D
11	Haloon (*Lepidiumsativum*)	15 G	13 H	8 D
12	Methry (*Trigonellafoenum-graecum*)	8 H	10 I	9 D
13	Kalonji (*Nigella sativa*)	12 GH	14 H	15 D
14	Ajwain (*Carumcopticum*)	10 H	9 I	13 D

III. Grain and Biomass yield (kg ha $^{-1}$)

The results of the study showed that significant variance among plant species was observed regarding biomass production during experimental period. Variation in plants biomass production observed due to variance in spreading ability, growth habit, response against edaphic conditions of area and adaptability. The results of the study accomplished that highest biomass was produced by Aloe barbadensemiller (61000 kg ha^{-1}) and it was statistically at par with *(Origanumvulgare)* 24667 kg ha^{-1}), while lowest biomass was produced by *(Lepidiumsativum)* (250 kg ha^{-1}). The results compared during the year 2021 differed significantly. While considering the year 2022 highest biomass was produced by Aloe barbadense miller (54000kg ha^{-1}) and lowest biomass was produced by *(Lepidiumsativum)* (322 kg ha^{-1}). According to the results of the year 2023 higher biomass yield was observed by Aloe barbadense miller (60000 kgha-1) and it was statistically at par with Origanumvulgare (25000 kg ha-1) while lowest biomass was obtained by *Carumcopticum* (337 kg ha-1). The results indicate that maximum weight of dry leaves and seed collection in Rabi season was recorded in Murrayakoenigii and significant differences among other plant species also observed during experiment duration. The biomass production in different plant species varied due to different plant spreading ability, growth habit and response against moisture stress and adaptability. The results of the study showed that highest biomass of leaves obtained from Aloe barbadense miller in perennial species followed by *Mentharoyleana* and *Origanumvulgare.* While in Rabi plants maximum yield in terms of seed collection was obtained in Nigella sativa followed by *Foeniculumvulgare* during study years while *Lepidiumsativum* seed yield remain low as compared to other medicinal Rabi seeds. The difference in seed yield varied due to phenotypic and genotypic differences in plants.

IV. Benefit Cost Analysis

The benefit cost ratio calculated as the revenue generated to total expenditure. The results of the study showed that maximum BCR value shown in Fig. 4 i.e. *Salvia rosmarinus* followed by *Mentharoyleana.* It indicated that on expenditure of one-rupee farmer will get benefit of 43.0 while the lowest BCR was 1.81 in *Lepidiumsativum.* The ratio was high in *Salvia rosmarinus* due to its high value in market while low BCR in *Lepidiumsativum* showed that with the expenditure of one-rupee farmer will get 1.81-rupee benefit that may be due to low market value of *Lepidiumsativum.* The results shown in fig.4 indicated that highest profit rate BCR 43.07 was obtained by *Salvia rosmarinus* followed by *Mentharoyleana*

(30.70), *Menthapiperita* (28.44) and *Aloe barbadense* miller (12.96). The fig.4 showed that net income was higher from high value medicinal plants than that of low value medicinal plants in the market.

Table5: Biomass / Yield Production (kg ha^{-1}) of selected plant species.

Sr.	Varieties	2021	2022	2023
1	Stevia (*Stevia rebaudiana*)	5500 G	5700 FG	6000 EFG
2	Alovera (*Aloe barbadense miller*)	61000 A	54000 A	60000 A
3	White Mint (*Menthapiperita*)	9540 D	8900 DEF	10000 D
4	Lemon Balm (*Melissa officinalis*)	9000 DE	7500	8000 DEFG
5	Mentha (*Mentha royleana*)	25550 C	23000 C	25453 C
6	Rose Mary (*Salvia rosmarinus*)	20500 C	19800 C	20000 C
7	Oregano (*Origanumvulgare*)	24667 AB	23700 B	25000 AB
8	Karri Patta (*Murrayakoenigii*)	5067 E	4750 E	5000 E
9	Tulsi (*Ocimumtenuiflorum*)	9245 D	9800 D	10000 D
10	Fennel (*Foeniculumvulgare*)	480 F	435 H	542 F
11	Haloon (*Lepidiumsativum*)	250 M	322 K	201 N
12	Methry (*Trigonellafoenum-graecum*)	435 G	374 H	503 G
13	Kalonji (*Nigella sativa*)	600 F	680 D	917 A
14	Ajwain (*Carumcopticum*)	320 L	350 J	337 K

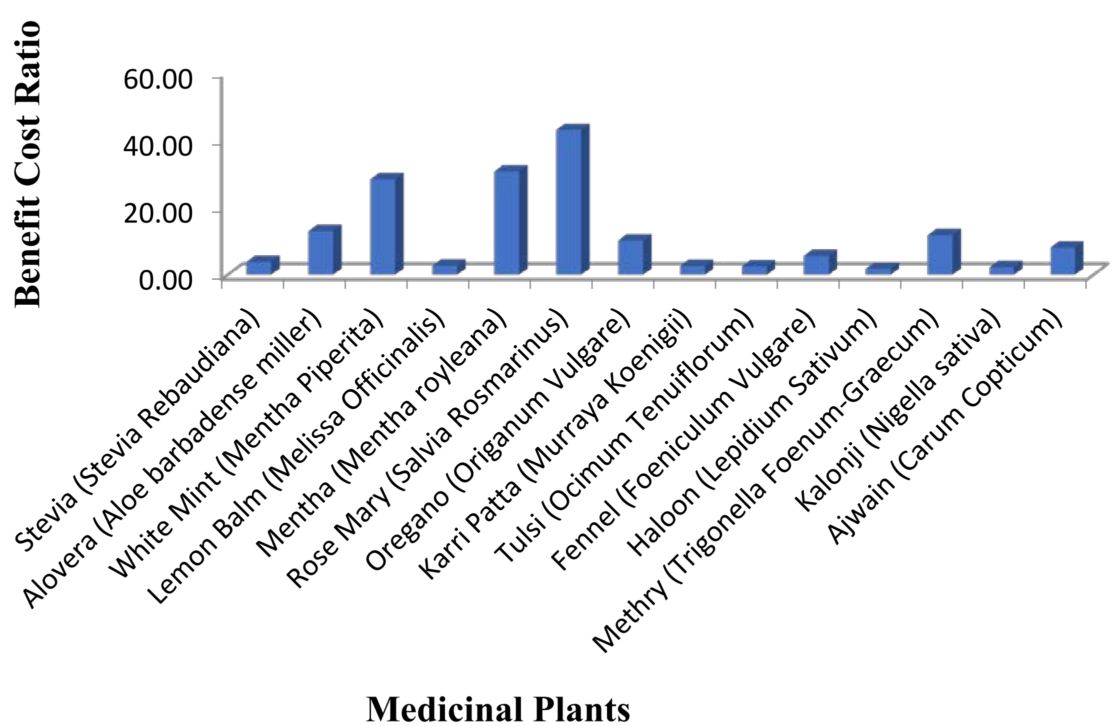

Fig. 4. Benefit Cost Ratio (BCR) of Medicinal Plants.

B. Soil Parameters

The cultivation of medicinal plants as a cover crop resulted in increase of SOM (soil organic matter), bring biological diversity and diminishsoil erosion. The rotation of medicinal plants, with their different root systems increased water holding capacity, water infiltration rate and water use efficiency, as studies conducted by Abidi (2019) and Delijouei et al. (2023) have sustained soil bioengineering via roots methods in mitigating soil erosion to deeper soil depths. Medicinal plant rotation by using medicinally important plants also augmented biological diversity and decrease the risk of disease or pestoutbreaks systems, optimizes the supply of nutrients in root channels, leadingplant cover bymedicinal has critical role for enlightening thephysic-chemical properties of the soil. The aggregates formed through cohesion of soil particles due to extensive plant root system of medicinal plants. Medicinal plants vegetation increase fertility level of degraded and poor soils (Munoz-Rojas et al., 2016), and due to exudates soil organic matter and decomposition of plant residues increased resulted in an increase in permeability, permeability soil porosity and retention of water. Medicinal plant cultivationhas positive effect on soil restoration by augmenting organic matter in soil through increased microbial activity. Medicinal plants use as a cover crop decreased runoff and improve soil physcochemical characteristics and soil structure through controlling erosion by minimizing mechanical movement in soil (Zuazo et al., 2006; Zuazo and Pleguezuelo, 2008). The soil micro-environment and nutrient enhancement is the result of incorporation of medicinal plant residues in soil producing complex interactions. In this way, the plant growth increased due to improvement of soil chemical and physical properties. Medicinal plants used for revegetation and reclamation of mine degraded lands and linked micro-organisms as they are considered nurse plants.

I. Bulk density

The data of bulk density of soil is presented in Figure 5. Mean high value of bulk density for study period was of oregano *(Ocimumtenuiflorum)* 1.67g cm^{-3} while lower value of 1.31 g cm^{-3} in *Origanumvulgare*). The difference in the extent of variation in bulk density might be due to exudates released by medicinal plants and root distribution pattern which closely relates to increased microbial activity, soil organic matter and increase of porosity of soil besides improved soil structure. Bulk density remains high of *Ocimumtenuiflorum* plant due to fibrous root system that can intertwine and form dense network in the soil. *Daynes* et al. (2013) has reported that medicinal plants help to the improvement of soil structure through the wide root systems. This can lead to compaction of soil overtime the results are comparable with Wael et al. (2015) which explain about effect of root characteristics on soil shear strength and bulk density.

II. Infiltration Rate

Infiltration rate can be affected by many factors including soil type, slope, vegetation and land use. Medicinal plant influenced infiltration rates by effecting soil structure,root penetration and water absorption,during study period it was observed that *Stevia rebaudiana* plant is statistically differentiated in increasing characteristics of soil infiltration rate by its root system which binds soil particles together, creating pore spaced that allow water to penetrate more easily study are correlated by root exudation and rhizosphere biology and respectively the influence of plant roots on soil resistance to penetration. The outcomes are robust evidence with Shi et al. (2023) of perennial peas impact on soil hydrological processes as specific vegetation type.

III. Organic Matter

Cultivation of medicinal plants have a momentous effect on SOM (soil organic matter) because soil and water conservation practices require long time to mark any serious impact on soil structure and sweep away top layer data in fig. 7 recorded showed that on an average maximum organic matter by *Murrayakoenigii* (0.83 %) followed by *Ocimumtenuiflorum* (0.82%) while lowest organic matter content was estimated in *Foeniculumvulgare* and *Aloe barbadense miller.*

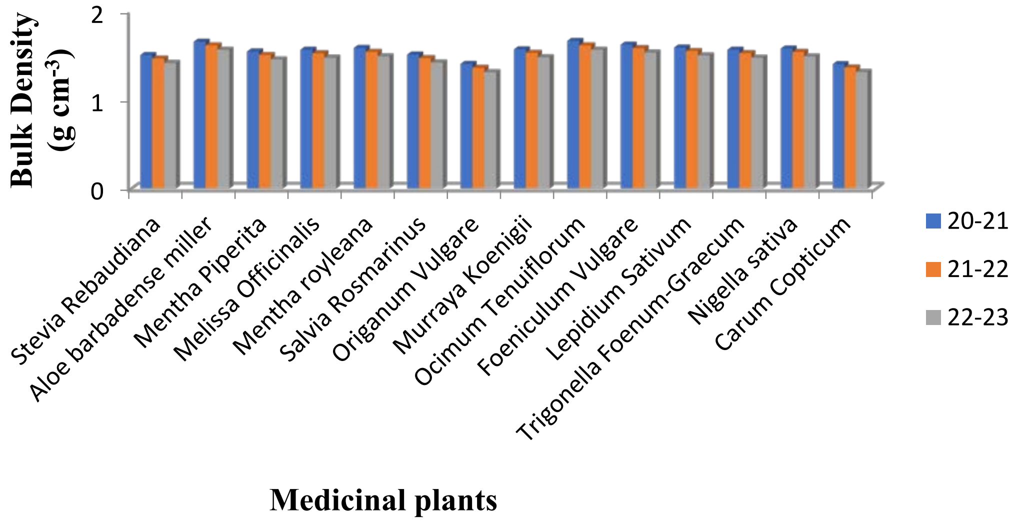

Fig. 5. Bulk density (g cm -3) of medicinal plants site.

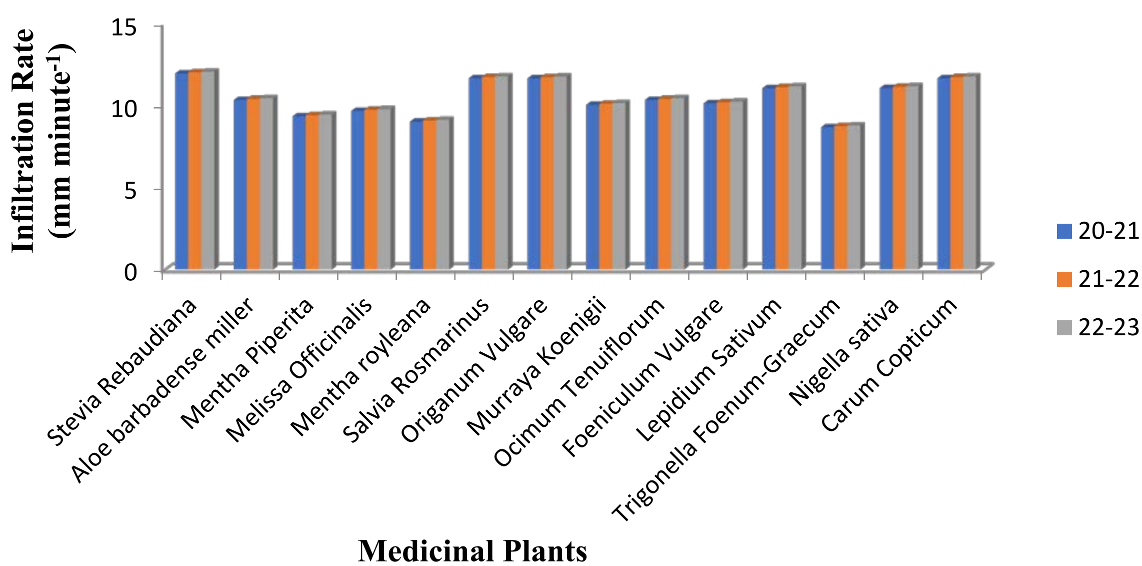

Fig. 6. Infiltration rate (mm min-1) medicinal plants site.

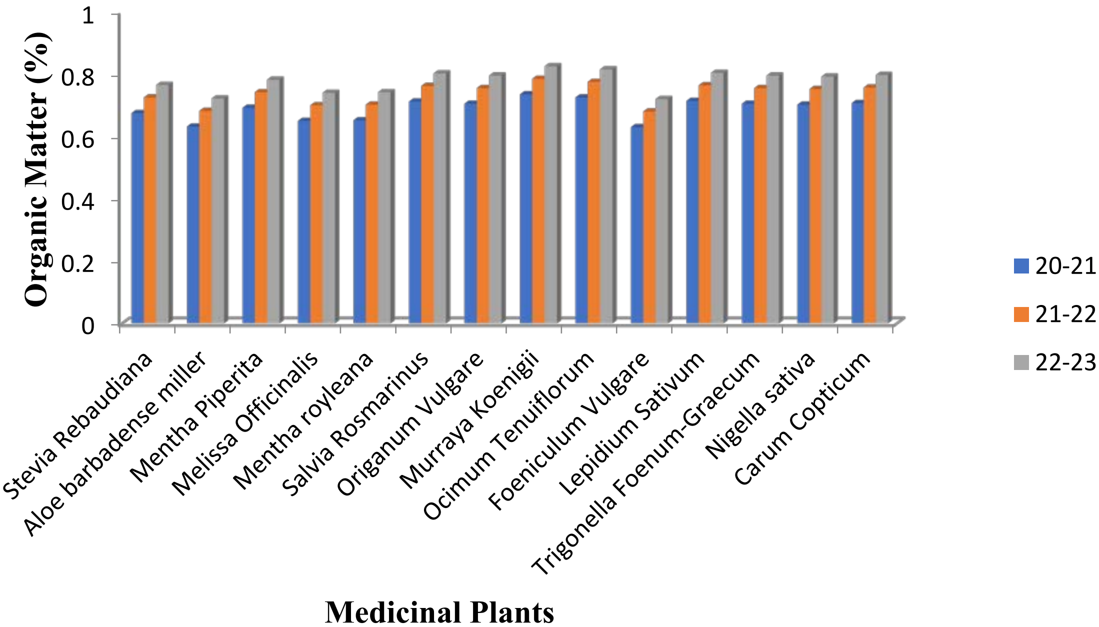

Fig. 7. Organic matter (%) of medicinal plants site.

CONCLUSION

The use of medicinal plants in young generation is diminishing. Elderly people still use herbal medicine for the treatment of different diseases but most of them prefer the conventional medicine. The conserved ethno-botanical knowledge based on the collective efforts of grandparents and parents. About 76% of the total land mass suffers from soil erosion due to low vegetative cover, low organic matter and steep topography. Cultivation of medicinal plants as an optional soil cover restores soil health and soil physicochemical properties. The medicinal plants extinct from nature due to their less use and lack of knowledge. Therefore, medicinal plants may be cultivated at degraded soils to reclaim soils of the country. Consequently, cultivation of medicinal plants at degraded soils will help to augment the multiplicity of medicinal plants and concurrently help to diminish the pressure on other crop lands and reclamation of the degraded land of the country with more economical benefits.

Authors' Contribution

Obaid ur Rehman and Rahina Kausar, proposed the main concept and involved in write up. Muhammad Rashid, assisted in establishing sequence of graphs and table section. Muhammad Imran Akram, did review and proof read of the manuscript. Ayesha Malik, collected field data. Muhammad Usman Mohsin, did provision of relevant literature. Asia Munir, did technical review before submission, Kouser Majeed Malik, did statistical analysis of field data. Saftain Ullah Khan, was involved in data arrangement and preparation of figures.

References

Ali, S.I. & Qaiser M., 1986. A phytogeographical analysis of the phanerogams of Pakistan and Kashmir. Proceedings of the Royal Society of Edinburgh, Section B: Biological Sciences. 89:89-101.

Asfaw 2022. A.review on the role of soil and water conservation practices on soil properyies improvement in Etopia .int.J.Agric.Sci.Food Technol.,8, 225-231.

Abidi, E., Saleh, H.R., Majnonian, B., & Deljouei, A., 2019. Soil fixation and erosion control by Haloxylon persicum roots in arid lands, Iran. J. Arid. Land, 11,

86-96.
Chen, S.-L., Yu, H., Luo, H.-M., Wu, Q., Li C.-F., &Steinmetz, A., 2016. Conservation and sustainable use of medicinal plants: problems, progress, and prospects. Chinese medicine. 11, 1-10.
Delijouei, A., Cislagh, A., Abdi, E., Borz, S.A., Majnounian, B., & Hales,T., 2023.Cimplications of hornebeam and beech root systems on slope stablity :From field and laboratory measurements to modelling methods. Plant Soil, 483, 547-572.
Daynes, C.N., Field, D.J., Saleeba, J.A. et al. 2013. Development and stabilisation of soil structure via interactions between organic matter, arbuscular mycorrhizal fungi and plant roots. Soil Biol. Biochem. 57, 683–694.
Jafari, M., Tavili, A., Panahi, F., Zandi Esfahan E., & Ghorbani, M., 2018. Erratum to: Reclamation of Arid Lands. In: Jafari, M., Tavili, A., Panahi, F., Zandi Esfahan, E. & Ghorbani, M. (eds.) Reclamation of Arid Lands. Cham: Springer International Publishing.
Jain, V., Momin, M., & Laddha, K., 2012. Murraya Koenigii: An Updated Review. International Journal of Ayurvedic And Herbal Medicine, 2 (4), 607-627.
Jones, D. and Rowe, E., 2017. Land reclamation and remediation, principles and practice. Encyclopedia of applied plant sciences. Elsevier Ltd.
Jia, Y.G., Xu, S.Z., & Xu, X.Q., 2012. Experimental study of introduction of perrenial pea in Hebei provence .South - north water divers. Water Sci. Technol., 10, 153-157.
Keesstra, S.D., Bouma, J., Wallinga, J., Tittonell, P., Smith, P., Cerdà, A., Montanarella, L., Quinton, J., Pachepsky, Y., & Van Der Putten, W.H., 2016. Forum paper: The significance of soils and soil science towards realization of the UN sustainable development goals (SDGS). Soil Discussions, 1-28.
Khadija, A.E., Mansour, S., Ali, B. & Abdelaziz, Y., 2021. Chemically degraded soil rehabilitation process using medicinal and aromatic plants. Environmental Science and Pollution Research International, 28, 73-93.
Munoz-Rojas, M., Erickson, T. E., Dixon, K. W., & Merritt, D. J., 2016. Soil quality indicators to assess functionality of restored soils in degraded semiarid ecosystems. Restoration Ecology, 24, S43-S52.
Shinwari, Z.K., & M. Qaiser. 2011. Efforts on conservation and sustainable use of medicinal plants of Pakistan. Pak. J. Bot. 43:5-10.
Shi, L., Dai, C., & Maruthaveeran, S., 2023. Application of Perennial Sweet Pea in Soil and Water Conservation. Applied Sciences, 13(19), 11075.
Wael, M., Nada & Blumenstein, O., 2015. Characterization and impact of newly synthesized superabsorbent hydrogel nanocomposite on water retention characteristics of sandy soil and grass seedling growth. International Journal of Soil Science, 10, 153-165.
Zuazo, V., Martínez, J.R.F., Pleguezuelo, R. et al., 2006. Soil-erosion and runoff prevention by plant covers in a mountainous area (SE Spain): Implications for sustainable agriculture. Environmentalist, 26, 309–319.
Zuazo, V., & Pleguezuelo, C., 2008. Soil-erosion and runoff prevention by plant covers. A review. Agron Sustain Dev., 28, 65–86.