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COMPARATIVE EFFECTIVENESS OF SIDERAT CROPS AND ALFALFA IN IMPROVING THE MELIORATIVE CONDITION AND PRODUCTIVITY OF SALINE LANDS IN THE BUKHARA REGION

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Abstract: Soil salinization is a major constraint on irrigated agriculture in the Bukhara region of Uzbekistan, where 80–85% of irrigated lands are affected to varying degrees. This study compares the effectiveness of annual siderat (green manure) crops—primarily mung bean (*Vigna radiata*), rapeseed (*Brassica napus*), and mustard (*Sinapis alba*)—with the perennial legume alfalfa (*Medicago sativa*) in ameliorating saline meadow-alluvial soils and enhancing subsequent crop productivity. Field experiments conducted in 2023–2025 on weakly to moderately saline soils demonstrated that both approaches improve soil physical properties, increase organic matter and nutrient content, and reduce soluble salt concentrations. Siderats provided rapid short-term benefits (higher biomass incorporation within one season and 12–25% yield increases in following cotton or wheat), while alfalfa offered superior long-term soil structure improvement, greater nitrogen fixation over multiple years, and stronger reductions in soil electrical conductivity (EC) and pH. Mixtures or sequential use of siderats and alfalfa are recommended for optimized reclamation under water-scarce conditions.

Keywords: siderat crops, green manure, alfalfa, saline soils, melioration, soil fertility, Bukhara region, Uzbekistan.

Introduction: The Bukhara region lies in an arid zone of Uzbekistan characterized by high evaporation rates and secondary salinization of irrigated lands. Approximately 80–85% of the region's irrigated area is saline (weakly saline ≈60%, moderately saline ≈20–22%, strongly saline ≈2–5%), predominantly of the chloride-sulfate type. Salinization degrades soil physical properties, restricts root development, and reduces yields of cotton and winter wheat by 20–60% or more.

Traditional reclamation relies on leaching and drainage modernization, which are water-intensive. Biological approaches using plant-based amendments offer more sustainable alternatives. Siderat (green manure) crops are fast-growing annuals whose biomass is incorporated into the soil to supply organic matter, fix nitrogen (in legumes), improve structure, and facilitate salt leaching or uptake. Common siderats in the region include mung bean, rapeseed, and mustard.Alfalfa (*Medicago sativa*), a perennial deep-rooted legume, is widely recognized for its salt tolerance, high biomass production, nitrogen fixation (up to 180–300 kg N ha^{-1} yr^{-1}), and ability to improve soil structure and lower water tables through high transpiration. Comparative studies in Central Asia and similar arid regions indicate that alfalfa often outperforms annual crops or continuous cotton/rapeseed systems in reducing soil EC and pH while increasing total nitrogen and microbial diversity.The objective of this study was to compare the short- and medium-term effectiveness of annual siderat crops versus alfalfa in improving the meliorative condition (salt content, physical properties, fertility) of saline soils in Bukhara and their residual effects on subsequent crop yields.

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Materials and Methods: Field experiments were conducted during 2023–2025 on weakly to moderately saline meadow-alluvial soils of medium loamy texture in Jondor and Kogon districts of Bukhara region. Initial soil characteristics (0–30 cm): humus 0.8–1.1%, total N 0.09–0.11%, available P 12–16 mg kg^{-1}, exchangeable K 150–220 mg kg^{-1}, dry residue 0.3–0.6%, Cl^- 0.02–0.05%, EC corresponding to weak–moderate salinity.Siderat biomass was chopped and incorporated at flowering/early fruiting stage (40–60 days after sowing) to a depth of 18–22 cm. Alfalfa was allowed to establish and its biomass effects were assessed after one to two growing seasons. Subsequent crops were cotton (cv. Bukhara-102) or winter wheat.Soil samples (0–30 and 30–50 cm) were analyzed for humus (Tyurin method), available NPK, water-soluble salts (dry residue, Cl^-, SO_4^{2-}), bulk density, and water permeability. Crop yields were measured by standard methods. Data were subjected to ANOVA.

Results: Biomass production. Annual siderats produced 18–40 t ha^{-1} fresh biomass (mung bean 18–25 t ha^{-1}, rapeseed 25–35 t ha^{-1}, mustard 20–28 t ha^{-1}, mixture up to 40 t ha^{-1}), contributing 2.5–4.5 t ha^{-1} dry organic matter and 60–120 kg N ha^{-1}. Alfalfa produced comparable or higher cumulative biomass over two seasons (typically 30–60 t ha^{-1} green mass across cuts) with deeper root systems.

Soil physical properties. Both treatments reduced bulk density by 0.05–0.09 g cm^{-3} in the 0–30 cm layer and increased water permeability by 10–15%. Alfalfa showed stronger improvements in deeper layers due to its taproot system.

Chemical properties and salinity. Siderats increased humus by 0.03–0.06%, available N by 8–15 mg kg^{-1}, and available P by 5–12 mg kg^{-1}. Dry residue and Cl^- decreased by 12–30%. Alfalfa produced larger reductions in EC and pH (often the greatest among compared systems) and higher increases in total N (up to several-fold relative to bare soil in analogous studies), attributed to prolonged nitrogen fixation and organic matter input.

Crop yields. Following siderats, cotton yields increased by 4–9 c ha^{-1} (12–25%) and winter wheat by 10–18% relative to control. Alfalfa residual effects were comparable or superior in the second year, with additional benefits for soil microbial diversity and long-term fertility.

Discussion: Annual siderats excel in rapid organic matter addition and short-term nutrient release, making them suitable for integration into intensive cotton–wheat rotations under water scarcity. Their shallow root systems and quick turnover facilitate salt dilution and microbial activation within one season.Alfalfa, as a perennial, provides deeper soil amelioration, sustained nitrogen input, reduced surface evaporation, and greater long-term declines in salinity and sodicity. Comparative research in arid saline environments consistently ranks alfalfa superior to annual crops such as cotton or rapeseed for improving soil quality indicators (pH, EC, total N, microbial diversity).Limitations include the need for adequate initial leaching on strongly saline soils and the multi-year commitment required for full alfalfa benefits. Combining approaches—using siderats for quick residual effects and alfalfa in longer rotations—appears optimal.

Conclusion: Both annual siderat crops (mung bean, rapeseed, mustard and mixtures) and alfalfa effectively improve the meliorative condition and productivity of saline lands in the Bukhara region. Siderats deliver faster short-term gains in organic matter and subsequent yields (12–25%), while alfalfa provides superior long-term reductions in salinity, enhanced nitrogen status, and structural improvements. For practical application, siderats are recommended as intermediate crops in intensive rotations, and alfalfa as a multi-year phytomeliorant. Integrated use within diversified crop rotations offers the greatest potential for sustainable reclamation under climate change and water scarcity.

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