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Research Article

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Seed Weight Standardization of Native Kuwaiti Plant Species: A Baseline for Restoration and Agricultural Planning

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ABSTRACT

Background: Standardizing native seed weight is essential for improving the efficiency of large-scale agriculture and ecological restoration in arid regions like Kuwait. Native species are well-adapted to local conditions, but their inconsistent seed metrics limit their use in restoration projects.

Results: This study evaluated the seed weight of 98 native Kuwaiti species using 10 replicates of 10 seeds each. Results revealed significant variability, with weights ranging from <0.005g (e.g., *Andrachne telephioides*) to >8g (e.g., *Acacia farnesiana*). Descriptive statistics demonstrated that larger seeds showed greater uniformity, supporting more accurate seeding rates and consistent crop establishment.

Conclusions: Seed weight standardization enhances germination, supports resource planning, and improves restoration outcomes. Despite challenges like genetic variability and equipment cost, the benefits in crop performance, seed quality, and restoration success are considerable. Implementing standardized seed weights fosters certification, stakeholder trust, and the sustainable use of native plants in ecological and agricultural systems.

Keywords: Seeds, Indigenous, Kuwait, Weight, Standardization

Introduction

Using indigenous species in a landscape plan can greatly enhance the local character and identity, particularly by incorporating plants that are historically connected to the region. This strategy not only contributes aesthetic value but also carries practical and economic benefits in bolstering the surrounding ecosystem. It is crucial to acknowledge that native plant species hold significant national importance and should be actively encouraged, especially given their involvement in ongoing desert rehabilitation and restoration projects in Kuwait. The use of locally adapted native seeds plays a critical role in ensuring the success and sustainability of desert restoration projects as they are uniquely suited to thrive in the local environment for long-term sustainability. Using native seeds in restoration projects allows practitioners to ensure that the reintroduced plants are well-suited to the local environment, including climate conditions, soil types, and other ecological factors.

There is a high demand for diverse native plant species in large-scale ecological restoration programs in Kuwait. These locally adapted native seeds play a crucial role in achieving long-term success in restoring Kuwait's ecosystems. However, the quality

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of native seeds remains a widespread issue globally, with few countries having established strict quality controls throughout the seed supply chain [1,2]. To address this constraint and ensure compliance with minimum standards comparable to internationally accepted rules and testing methodologies used for commercial crop seeds, it is important to develop a methodological framework for seed quality assurance [3].

The sustainable collection or procurement of native seeds in the required volumes and diversity is a significant constraint for restoration practitioners worldwide. To simplify mass production, it is necessary to standardize seed weight and quantity. Standardization of seeds refers to the process of establishing uniform criteria and procedures for evaluating the quality, characteristics, and performance of seeds [4,5].

Developing standardized methods involves seed testing, certification, and labeling is crucial for ensuring consistency and reliability in the seed industry. Key metrics, such as grain yield (kg ha^{-1}) and the mass of a thousand seeds (g), are important for improving economic analysis and calculating profitability per unit area. Standardized seed weight ensures that each batch of seeds is uniform in size and mass, which leads to consistent planting rates. This uniformity facilitates more predictable germination rates and seedling development, resulting in more uniform crop stands. Such consistency is especially important in large-scale production systems, where it can significantly impact overall crop yield and quality [6]. Seeds of uniform weight generally have similar physiological and biochemical properties, which enhances germination rates and seedling vigor [7,8]. By reducing the occurrence of weak or underdeveloped plants, standardizing seed weight ensures that only high-quality seeds are used, leading to stronger plants and more robust crop performance [9]. Moreover, accurate seed weight data improves planning and resource management. Standardized seed weight allows farmers and producers to optimize planting strategies and input applications, leading to cost savings and more effective use of agricultural resources, thus contributing to the overall sustainability of farming practices [10]

Additionally, incorporating seed procurement models and planning for seed use early in restoration projects can effectively address issues related to low genetic diversity and poor-quality native. Standardizing native seed weight ensures precision in agricultural research while supporting conservation and the sustainable use of diverse crop species. It allows reliable comparisons among varieties, fostering improved cultivation practices and the preservation of traditional knowledge. Moreover, standardized seed weight enhances storage efficiency, safeguards genetic diversity, and promotes fair, transparent trade by guaranteeing that buyers receive seeds of consistent quantity and quality. As well as crucial towards planning and evaluating seed-based restoration projects, allowing researchers and practitioners to accurately calculate the required quantity of seeds, ensuring quantities meet the requirements for successful restoration. By improving the accuracy and cost-effectiveness of these projects, standardized seed weight contributes to overall biodiversity conservation initiatives.

There are however several challenges associated with seed standardization. Achieving precise and consistent measurements of seed weight can be difficult, especially with small or irregularly shaped seeds. Advanced technologies and calibration techniques are necessary for accurate measurement, but these can be resource-intensive [11]. Additionally, variability in seed sources due to environmental factors or genetic differences can further complicate standardization efforts. Addressing these variations requires rigorous quality control measures and potential genetic improvements in seed lines [12]. Furthermore, implementing standardization practices often involves additional costs, such as investments in specialized equipment and training for accurate measurement and handling. Balancing these costs with the benefits of standardization is crucial for the feasibility of mass production systems [13].

This study aims to quantify seed weight variability among native Kuwaiti plant species and assess the implications of weight standardization for seed-based ecological restoration and agricultural production. By establishing baseline data, the study contributes to developing standardized practices essential for advancing restoration science and sustainable seed systems in arid environments.

Materials and Methods

Descriptive statistics was analyzed using Minitab 17 software. Seed weight was determined in 10 replicates of 10 seeds each. Each replicate is weighed in grams using an AE Adam PW124 Scale (d= 0.0001g). Descriptive statics of variance, mean, standard deviation, minimum and maximum seed weight were calculated. Analysis was performed at the Public Authority of Agriculture and Fisheries (PAAF), Ardiyah Nursery Lab.

Results

Seed weight was evaluated for 98 native Kuwaiti plant species using 10 replicates of 10 seeds per species. Measurements were taken with a precision scale (0.0001g resolution), and descriptive statistics; including mean, standard deviation, variance, and range, were calculated for each species (Table. 1).

The results revealed substantial variability in seed weight. Some species, such as *Andrachne telephioides* and *Gypsophila capillaris*, exhibited extremely low seed weights (<0.005g), while others, such as *Acacia farnesiana*, *Prosopis cineraria*, and *Rhanterium epapposum*, had weights exceeding 3g and up to 8g. Species with larger seeds generally demonstrated lower variation across replicates, suggesting better consistency in seed mass.

Table 1: Seed weight of native species. Each replicate is weighed in grams. Average weight, variance, standard deviation, and coefficient of variation.

No.	Plant name	N	Mean (g)	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum	Range
1	*Aaronsohnia factorovskyi*	10	0.00612	0.000141	0.000447	0.0053	0.005825	0.00625	0.006425	0.0068	0.0015
2	*Acacia farnesiana* (L.) Willd	10	8.425	0.0493	0.1559	8.1817	8.2804	8.4429	8.5266	8.703	0.5213
3	*Acacia tortilis* (Forssk.) Hayne	10	2.2319	0.0258	0.0817	2.1062	2.1698	2.2361	2.3152	2.3483	0.2421
4	*Aegilops neglecta* Req. ex Bertol.	10	0.25834	0.00988	0.03125	0.2009	0.237	0.2589	0.28578	0.2953	0.0944
5	*Aerva javanica* (Burm.f.) Juss. ex Schult.	10	0.01485	0.000864	0.002733	0.0075	0.014525	0.01585	0.0164	0.0165	0.009
6	*Aizoon hispanicum* L.	10	0.00438	0.000155	0.000492	0.0038	0.003975	0.00425	0.004825	0.0053	0.0015
7	*Alhagi maurorum* var. *maurorum*	10	0.05374	0.00151	0.00477	0.0455	0.05053	0.055	0.0577	0.0583	0.0128
8	*Allium sphaerocephalon* L.	10	0.0426	0.0198	0.0627	0.0208	0.0216	0.0226	0.0249	0.221	0.2002
9	*Anabasis setifera* Moq.	10	0.004322	0.000138	0.000415	0.0035	0.0041	0.0043	0.0046	0.0049	0.0014
10	*Anagallis arvensis* L.	10	0.00832	0.000175	0.000553	0.0074	0.00785	0.00835	0.0087	0.0093	0.0019
11	*Andrachne telephioides* L.	10	0.00212	0.000136	0.000432	0.0013	0.00185	0.00215	0.002425	0.0028	0.0015
12	*Anisosciadium lanatum* Boiss.	10	0.5385	0.0309	0.0978	0.4035	0.4359	0.5764	0.6231	0.651	0.2475
13	*Anthemis deserti* Boiss.	10	0.00352	0.0002	0.000632	0.0026	0.0029	0.00355	0.0042	0.0043	0.0017
14	*Arnebia decumbens* (Vent.) Cosson & Kralik	10	1.6582	0.0336	0.1063	1.5368	1.5666	1.6286	1.7311	1.8841	0.3473
15	*Astragalus annularis* Forssk.	10	0.16445	0.00102	0.00323	0.1609	0.16143	0.16415	0.16805	0.1691	0.0082
16	*Astragalus corrugatus* Benth.	10	0.16023	0.00309	0.00979	0.1412	0.1545	0.1603	0.16798	0.1741	0.0329
17	*Astragalus hauarensis* Boiss.	10	0.02616	0.00123	0.0039	0.0174	0.02375	0.02695	0.02937	0.0303	0.0129
18	*Astragalus lagenarius*	10	0.28007	0.00222	0.00703	0.268	0.27547	0.27975	0.28358	0.2931	0.0251
19	*Astragalus schimperi* Boiss.	10	0.1245	0.00106	0.00336	0.12	0.12218	0.1234	0.12715	0.1305	0.0105
20	*Astragalus sieberi* DC.	10	0.1586	0.00188	0.00594	0.1504	0.15395	0.15815	0.16225	0.1705	0.0201
21	*Astragalus tribuloides* Delile	10	0.06792	0.00144	0.00455	0.0572	0.06542	0.06895	0.0709	0.0728	0.0156
22	*Brassica tournefortii* (Gouan).	10	0.01721	0.000543	0.001716	0.0146	0.015825	0.01685	0.0188	0.0197	0.0051
23	*Bromus* sp.	10	0.0555	0.00429	0.01357	0.0443	0.04562	0.0498	0.06133	0.0851	0.0408
24	*Cakile arabica* Velen.	10	0.15756	0.00648	0.02049	0.1309	0.13935	0.14955	0.17708	0.1889	0.058
25	*Calligonum comosum* L'Hér.	10	0.4878	0.0149	0.0472	0.4049	0.457	0.4936	0.5233	0.5683	0.1634
26	*Calotropis procera* (Aiton) W.T. Aiton	10	0.12224	0.00143	0.00453	0.1174	0.1181	0.12225	0.12375	0.133	0.0156
27	*Carduus pycnocephalus* L.	10	0.01937	0.00033	0.001042	0.0177	0.018575	0.0193	0.02025	0.0209	0.0032
28	*Carrichtera annua* (L.) DC.	10	0.00798	0.000278	0.00088	0.007	0.0073	0.00755	0.008675	0.0096	0.0026
29	*Centaurea bruguierana* Coss. & Durieu	10	0.0054	0.000112	0.000353	0.0047	0.00515	0.0055	0.0057	0.0058	0.0011
30	*Centaurea pseudosinaica* Borbás	10	0.01294	0.000269	0.000851	0.0115	0.012275	0.013	0.013775	0.0141	0.0026
31	*Cistanche tubulosa* (Schenk) Hook.f.	10	0.00423	0.000995	0.003145	0.0005	0.00135	0.00365	0.007525	0.0081	0.0076
32	*Citrullus colocynthis* (L.) Schrad.	10	3.3068	0.0162	0.0511	3.2379	3.2559	3.306	3.3504	3.3932	0.1553
33	*Cleome amblyocarpa* Barratte & Murb.	10	0.02071	0.000882	0.00279	0.0174	0.0188	0.01975	0.022675	0.0256	0.0082

No.	Plant name	N	Mean (g)	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum	Range
34	*Convolvulus arvensis* L.	10	0.09486	0.0011	0.00346	0.0903	0.092	0.0945	0.09765	0.1014	0.0111
35	*Convolvulus cephalopodus*	10	0.01392	0.000263	0.000831	0.0124	0.013275	0.0141	0.01435	0.0154	0.003
36	*Conyza bonariensis* (L.) Cronquist	10	0.00466	0.000187	0.000591	0.0038	0.00415	0.0046	0.00515	0.0056	0.0018
37	*Cordia sinensis* Lam.	10	1.9245	0.0868	0.2744	1.6061	1.6985	1.9102	2.064	2.5172	0.9111
38	*Cyperus conglomeratus* Rottb.	10	0.01589	0.0003	0.000949	0.0149	0.015275	0.0156	0.016275	0.018	0.0031
39	*Datura innoxia* Mill.	10	0.10583	0.00266	0.00841	0.0902	0.09813	0.10805	0.11272	0.1156	0.0254
40	*Deverra triradiata* (Hochst. ex Boiss.) Hochst. ex Boiss.	10	0.04432	0.00218	0.00689	0.0332	0.03915	0.044	0.0512	0.0534	0.0202
41	*Dipcadi erythraeum* Webb & Berthel.	10	0.05809	0.00113	0.00358	0.0526	0.0558	0.05795	0.0601	0.0643	0.0117
42	*Diplotaxis harra* (Forssk.)	10	0.0064	0.000111	0.00035	0.0058	0.0061	0.00645	0.006725	0.0069	0.0011
43	*Ducrosia anethifolia* (DC.) Boiss.	10	0.02839	0.000876	0.00277	0.0227	0.026675	0.0288	0.0302	0.0321	0.0094
44	*Echinops blanchianus* Boiss. & Hausskn.	10	0.27397	0.00577	0.01824	0.2589	0.26033	0.27	0.28092	0.3114	0.0525
45	*Echium rauwolfii* Delile	10	1.6741	0.0146	0.0461	1.61	1.6164	1.6858	1.6993	1.7491	0.1391
46	*Echium webbii* Coincy	10	0.18684	0.00267	0.00846	0.1717	0.18202	0.1883	0.1918	0.1991	0.0274
47	*Ephedra alata* Decne.	10	0.08813	0.0089	0.02813	0.0541	0.05822	0.096	0.11468	0.1264	0.0723
48	*Fagonia indica* Burm.f.	10	0.00868	0.000295	0.000933	0.0067	0.00815	0.00865	0.0094	0.0099	0.0032
49	*Farsetia aegyptia* Turra subsp. *aegyptia*	10	0.0431	0.00129	0.00406	0.0329	0.0424	0.04415	0.04528	0.0477	0.0148
50	*Filago pyramidata* L.	10	0.47642	0.00795	0.02514	0.4377	0.45943	0.47125	0.50045	0.5215	0.0838
51	*Gynandriris sisyrinchium*	10	0.33855	0.0052	0.01644	0.3183	0.32937	0.3336	0.34785	0.3754	0.0571
52	*Gypsophila capillaris* (Forssk.) *C. Chr.*	10	0.00422	0.000278	0.00088	0.0029	0.00315	0.0044	0.005	0.0052	0.0023
53	*Helianthemum lippii* (L.) Dum.Cours.	10	0.00218	0.000104	0.000329	0.0016	0.001975	0.00215	0.0025	0.0027	0.0011
54	*Lotus halophilus* Boiss.	10	0.00322	0.000105	0.000333	0.0028	0.002975	0.00315	0.003475	0.0038	0.001
55	*Lycium shawii* Roem. & Schult.	10	0.12184	0.00158	0.005	0.1123	0.11685	0.12395	0.1255	0.1272	0.0149
56	*Malcolmia grandiflora* (DC.) Boiss	10	0.00519	0.000735	0.003286	0.0017	0.002125	0.00415	0.008775	0.0095	0.0078
57	*Matthiola longipetala* (Vent.) DC.	10	0.34222	0.0065	0.01949	0.3221	0.3257	0.3366	0.3561	0.3789	0.0568
58	*Melilotus indicus* (L.) All.	10	0.01931	0.000389	0.001231	0.0173	0.01855	0.01935	0.019925	0.0218	0.0045
59	*Mesembryanthemum nodiflorum* L.	10	0.225	0.0048	0.01517	0.2033	0.21215	0.2256	0.23392	0.2554	0.0521
60	*Moltkiopsis ciliata* (Forssk.) I.M.Johnst.	10	0.01462	0.000913	0.002888	0.0106	0.0117	0.01465	0.016425	0.019	0.0084
61	*Neurada procumbens* L.	10	1.9797	0.081	0.2561	1.6844	1.8004	1.9609	2.0273	2.6187	0.9343
62	*Nitraria retusa* (Forssk.) Asch.	10	0.34676	0.00866	0.02737	0.3	0.32398	0.34555	0.37303	0.3825	0.0825
63	*Ochradenus baccatus* Delile	10	0.01083	0.00027	0.000855	0.0095	0.010075	0.0109	0.01165	0.0118	0.0023
64	*Oligomeris linifolia* (Vahl) J.F.Macbr.	10	0.00496	0.000202	0.000638	0.0041	0.004375	0.00485	0.0056	0.0059	0.0018
65	*Onobrychis aucheri* Boiss.	10	3.5166	0.066	0.2087	3.217	3.3686	3.5391	3.6239	3.9323	0.7153
66	*Onobrychis ptolemaica* (Delile) DC.	10	0.3467	0.0127	0.0402	0.2967	0.317	0.3295	0.3866	0.4097	0.113
67	*Panicum turgidum* Forssk.	10	0.406	0.2	0.631	0.196	0.202	0.208	0.212	2.201	2.006
68	*Pennisetum divisum* (J.F.Gmel.) Henrard	10	0.02553	0.00194	0.00613	0.0184	0.01908	0.0246	0.0313	0.0346	0.0162

No.	Plant name	N	Mean (g)	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum	Range
69	*Plantago amplexicaulis* Cav.	10	0.04232	0.00149	0.0047	0.0365	0.03733	0.04185	0.04598	0.0498	0.0133
70	*Plantago boissieri* Hausskn.	10	0.00662	0.000545	0.001725	0.0031	0.005575	0.00665	0.008075	0.0089	0.0058
71	*Plantago coronopus* L.	10	0.00214	0.000437	0.001382	0.0006	0.00145	0.00165	0.0026	0.0049	0.0043
72	*Plantago ovata* Forssk.	10	0.01399	0.00074	0.002341	0.011	0.012175	0.01335	0.0157	0.0188	0.0078
73	*Prosopis cineraria* (L.) Druce	10	3.72	0.0307	0.0972	3.5925	3.6266	3.7152	3.8077	3.8725	0.28
74	*Pteranthus dichotomus* Forssk.	10	0.2194	0.016	0.0505	0.1461	0.1964	0.212	0.2321	0.3408	0.1947
75	*Pulicaria undulata* (L.) C.A. Mey.	10	0.00109	0.000322	0.001017	0.0003	0.000375	0.00085	0.00125	0.0037	0.0034
76	*Reichardia tingitana* (L.) Roth	10	0.00465	0.00101	0.0032	0.002	0.00208	0.0024	0.00827	0.0088	0.0068
77	*Reseda muricata* C.Presl	10	0.00425	0.000167	0.000528	0.003	0.00405	0.0043	0.00465	0.0048	0.0018
78	*Rhanterium epapposum* Oliv.	10	5.242	0.103	0.325	4.782	4.853	5.347	5.573	5.587	0.804
79	*Rumex spinosus* L.	10	0.06542	0.00311	0.00984	0.0492	0.05828	0.0651	0.07435	0.081	0.0318
80	*Rumex vesicarius* L.	10	2.4294	0.0252	0.0797	2.2964	2.3536	2.4636	2.4788	2.5267	0.2303
81	*Salsola imbricata* Forssk.	10	0.00465	0.000327	0.001034	0.003	0.003575	0.00485	0.005625	0.0058	0.0028
82	*Salsola jordanicola* Eig.	10	0.04547	0.000886	0.002803	0.0407	0.042075	0.0469	0.0473	0.0485	0.0078
83	*Salvadora persica* L.	10	1.6653	0.0223	0.0704	1.5567	1.5987	1.6723	1.7169	1.7711	0.2144
84	*Salvia aegyptiaca* Linn.	10	0.05088	0.000758	0.002396	0.0477	0.04865	0.05085	0.0529	0.0543	0.0066
85	*Salvia lanigera* Poir.	10	0.02145	0.00493	0.01558	0.0012	0.01255	0.0197	0.026	0.0592	0.058
86	*Salvia spinosa* L.	10	0.04042	0.00169	0.00533	0.0326	0.03628	0.03975	0.04585	0.0477	0.0151
87	*Sclerocephalus arabicus* Boiss.	10	0.8203	0.0506	0.1601	0.6179	0.6923	0.8308	0.8731	1.1821	0.5642
88	*Scrophularia deserti* Delile	10	0.00373	0.000047	0.000149	0.0035	0.0036	0.0037	0.003825	0.004	0.0005
89	*Senecio glaucus* L.	10	0.00572	0.000102	0.000322	0.0051	0.0054	0.0058	0.006	0.0061	0.001
90	*Silene arabica* Boiss.	10	0.00445	0.000073	0.000232	0.004	0.0043	0.0044	0.004625	0.0048	0.0008
91	*Silene conoidea* L.	10	0.12439	0.00104	0.00329	0.1187	0.12245	0.12405	0.12623	0.1304	0.0117
92	*Silene villosa* Forssk.	10	0.00425	0.000083	0.000264	0.0038	0.004	0.0043	0.004425	0.0047	0.0009
93	*Solanum nigrum* L.	10	0.549	0.0161	0.0508	0.4415	0.5238	0.5504	0.5925	0.6025	0.161
94	*Tetraena qatarensis* (Hadidi) Beier & Thulin.	10	0.00477	0.000145	0.000457	0.0043	0.00445	0.0046	0.005025	0.0057	0.0014
95	*Tribulus macrocarpus* F. Muell.	10	0.25855	0.00952	0.03012	0.2026	0.2396	0.2622	0.2815	0.2984	0.0958
96	*Vaccaria hispanica* (Mill.) Rauschert	10	0.04211	0.000798	0.002522	0.0386	0.03965	0.042	0.0444	0.0461	0.0075
97	*Zilla spinosa* (L.) Prantl	10	1.3725	0.0286	0.0904	1.146	1.341	1.3916	1.4267	1.4625	0.3165
98	*Ziziphus nummularia* (Burm.f.) Wight & Arn.	10	1.4856	0.061	0.1929	1.2731	1.2987	1.4649	1.6209	1.8919	0.6188

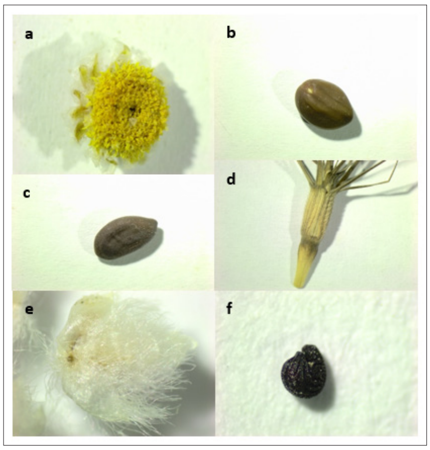

Figure 1: (a) *Aaronsohnia factorovskyi*, (b) *Acacia farnesiana* (L.) W, (c) *Acacia tortilis* (Forssk.), *(d) Aegilops neglecta* Req. ex Bertol, *(e) Aerva javanica* (Burm.f.) Juss. ex Schult.*, (f) Aizoon hispanicum* L.

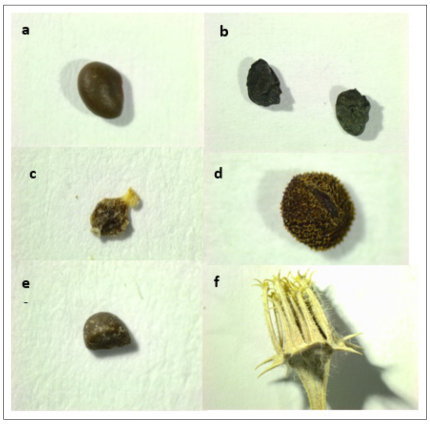

Figure 2: (*a) Alhagi maurorum var. mau, (b) Allium sphaerocephalon* L.*, (c) Anabasis setifera* Moq.*, (d) Anagallis arvensis* L.*, (e) Andrachne telephioides* L. *(f) Anisosciadium lanatum Boiss.*

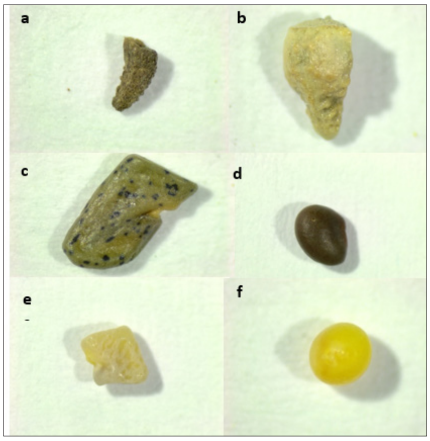

Figure 3: (*a) Anthemis deserti* Boiss.*, (b) Arnebia decumbens* (Vent.) Cosson & Kralik*, (c) Astragalus corrugatus* Boiss.*, (d) Alhagi maurorum* var. mau.*, (e) Astragalus hauarensis* Boiss.*, (f) Astragalus schimperi* Boiss*.*

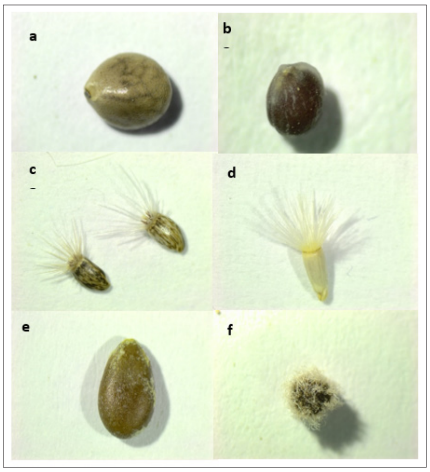

Figure 4: *(a) Astragalus sieberi* DC.*, (b) Brassica tournefortii (*Gouan).*, (c) Bromus* sp.*, (d) Cakile arabica* Velen.*, (e) Calligonum comosum* L'Hér.*, (f) Calotropis procera* (Aiton) W.T. Aiton

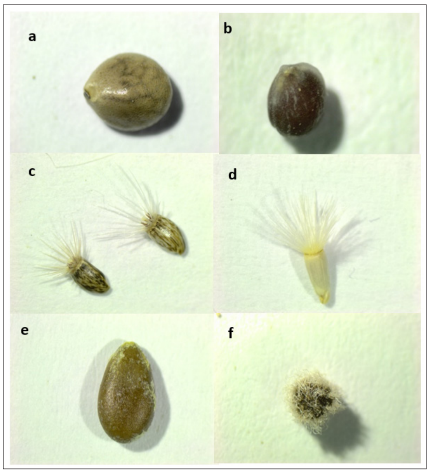

Figure 5: *(a) Carduus pycnocephalus* L.*, (b) Carrichtera annua* (L.) DC.*, (c) Centaurea bruguierana* Coss. & Durieu*, (d) Centaurea pseudosinaica* Borbás*, (e) Citrullus colocynthis* (L.) Schrad.*, (f) Cleome amblyocarpa* Barratte & Murb.

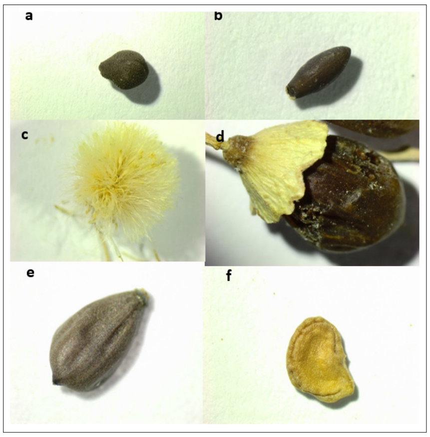

Figure 6: *(a) Convolvulus arvensis* L.*, (b) Convolvulus cephalopodus, (c) Conyza bonariensis* (L.) Cronquist*, (d) Cordia sinensis* Lam.*, (e) Cyperus conglomeratus* Rottb.*, (f) Datura innoxia* Mill.

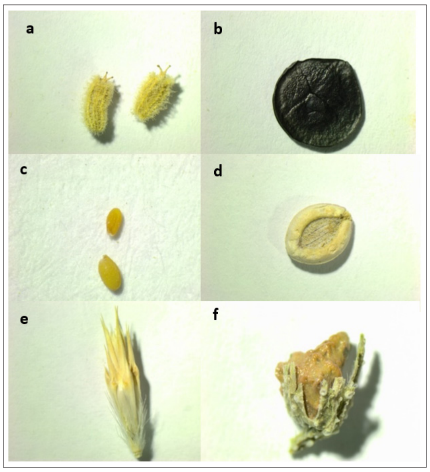

Figure 7: *(a) Deverra triradiata* (Hochst. ex Benth.) Hochst. ex Boiss*., (b) Dipcadi erythraeum* Webb & Berthel.*, (c) Diplotaxis harra* Forssk. Boiss.*, (d) Ducrosia anethifolia* (DC.) Boiss.*, (e) Echinops blanchianus* Boiss. & Hausskn.*, (f) Echium rauwolfii* Delile

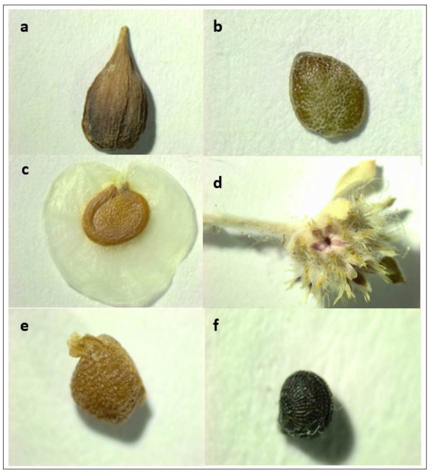

Figure 8: *(a) Ephedra alata* Decne*. (b) Fagonia indica* Burm.f. *(c) Farsetia aegyptia* Turra subsp. *aegyptia., (d) Filago pyramidata* L.*, (e) Gynandriris sisyrinchium, (f) Gypsophila capillaris* (Forssk.) C. Chr..

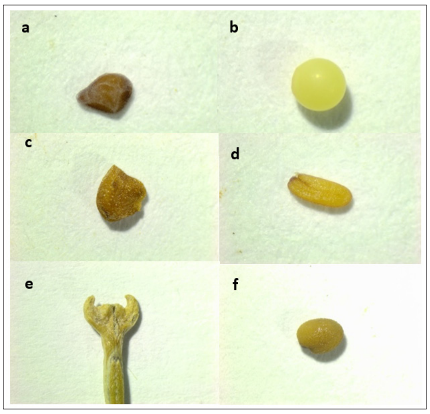

Figure 9: (*a) Helianthemum lippii* (L.) Dum. Cours.*, (b) Lotus halophilus* Boiss.*, (c) Lycium shawii* Roem. & Schult.*, (d) Malcolmia grandiflora* (DC.) Boiss*, (e) Matthiola longipetala* (Vent.) DC.*, (f) Melilotus indicus* (L.) All.

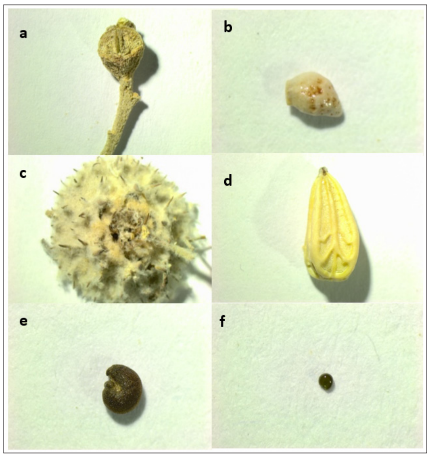

Figure 10: *(a) Mesembryanthemum nodiflorum* L.*, (b) Moltkiopsis ciliata* (Forssk.) I.M. Johnst.*, (c) Neurada procumbens* L.*, (d) Nitraria retusa* (Forssk.) Asch.*, (e) Ochradenus baccatus* Delile*, (f) Oligomeris linifolia* (Vahl) J.F. Macbr.

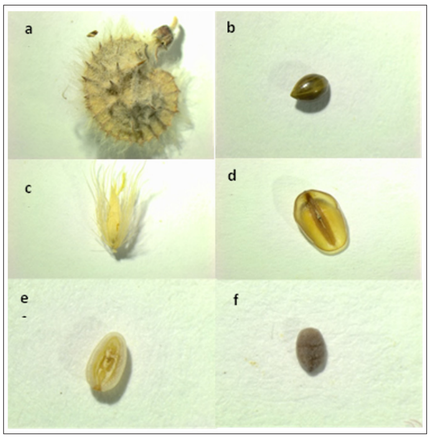

Figure 11: (*a) Onobrychis ptolemaica* (D)*, (b) Panicum turgidum* Forssk.*, (c) Pennisetum divisum* (J.F.Gmel.) Henrard*, (d) Plantago amplexicaulis* Cav*, (e) Plantago boissieri* Hausskn.*, (f) Plantago coronopus* L.

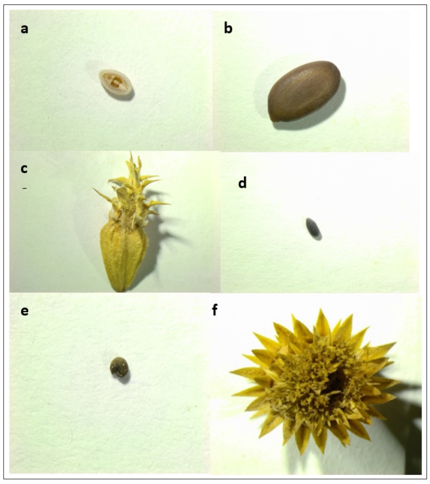

Figure 12: *(a) Plantago ovata* Forssk.*, (b) Prosopis cineraria* (L.) Druce*, (c) Pteranthus dichotomus* Forssk.*, (d) Reichardia tingitana* (L.) Roth*, (e) Reseda muricata* C. Presl.*, (f) Rhanterium epapposum* Oliv.

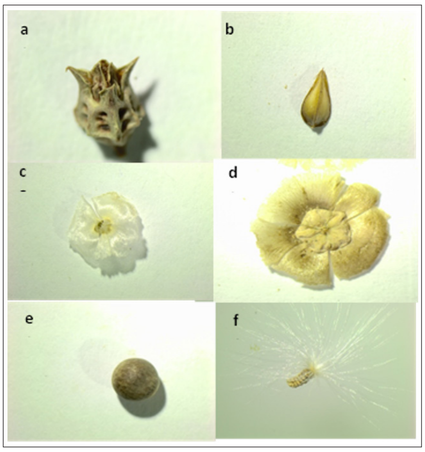

Figure 13: *(a) Rumex spinosus* L., *(b) Rumex Vesicarius* L., *(c) Salsola imbricata* Forssk*, (d) Salsola jordanicola* Eig., *(e) Salvadora persica* L., *(f) Salvia aegyptiaca* L.

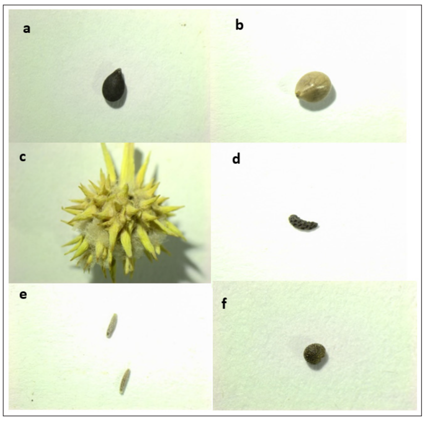

Figure 14: *(a) Salvia lanigera* Poir., *(b) Salvia spinosa* L., *(c) Sclerocephalus arabicus* Boiss., *(d) Scrophularia deserti* Delile, *(e), Senecio glaucus* L. *(f) Silene arabica* Boiss.

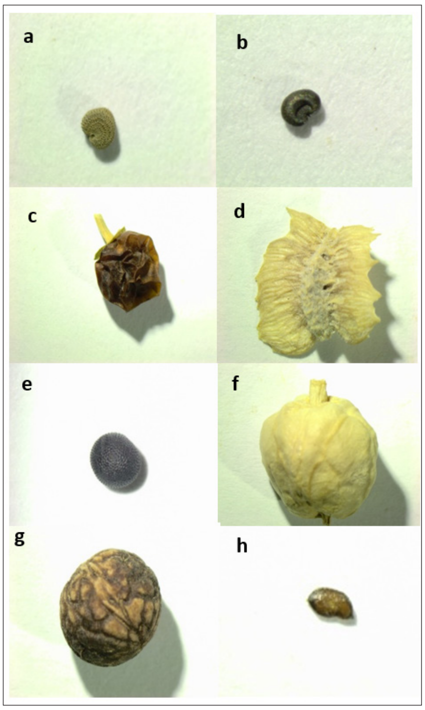

Figure 15: *(a) Silene conoidea* L., *(b) Silene villosa* Forssk.,*(c) Solanum nigrum* L., *(d) Tribulus macropterus* F. Muell., *(e) Vaccaria hispanica* (Mill.) Rauschert, *(f) Zilla spinosa* (L.) Prantl., *(g) Ziziphus nummularia* (Burm.f.) Wight & Arn., *(h) Tetraena qatarensis* (Hadidi) Beier & Thulin.

Discussion

The substantial variation observed in seed weights across the 98 native Kuwaiti species highlights the need for establishing standardized seed metrics, particularly in large-scale ecological restoration and agricultural initiatives. Seed weight is a key determinant of germination success, seedling vigor, and crop establishment, traits that are especially critical in arid environments where plant establishment is often challenged by water scarcity and poor soil conditions [8,14].

Species such as *Acacia farnesiana* and *Prosopis cineraria*, which exhibited relatively high and uniform seed weights, may be especially suitable for mechanized sowing and commercial-scale seed production. Their consistency facilitates accurate estimation of seeding rates, promotes even germination, and reduces the risk of under or over-seeding [15]. Such standardization improves planning, minimizes resource waste, and supports restoration goals by enhancing seedling establishment success.

However, seed weight is influenced by both genetic and environmental factors, including maternal plant condition, seed maturation stage, and ecological stressors [16]. These sources of variability complicate the development of fixed weight standards and necessitate region-specific benchmarks and adaptive protocols. Furthermore, the irregular shape and minute size of seeds in species such as *Gypsophila capillaris* or *Andrachne telephioides* pose technical challenges, requiring precision weighing tools and calibrated methodologies [12].

From an operational perspective, the implementation of seed weight standardization can contribute to the development of seed certification schemes and quality assurance protocols, which are largely lacking in native seed markets, particularly in the Gulf region [3]. Establishing such frameworks would improve traceability, transparency, and confidence among restoration practitioners, suppliers, and policymakers [17].

Ultimately, while seed weight standardization alone cannot account for all aspects of seed quality, it remains a valuable proxy for physiological performance, restoration planning, and economic efficiency. Future research should integrate seed weight with germination traits, genetic purity, and ecological function to support the development of comprehensive seed quality assessment systems in arid and semi-arid ecosystems.

Conclusion

Establishing consistent native seed weight is a vital practice for enhancing the efficiency and success of large-scale production systems in Kuwait. This ensures uniform planting, improves crop yields, and supports sustainable agricultural practices. Despite challenges, such as genetic purity, physical purity, viability, and vigor the advantages of standardization in terms of seed quality, resource management, and economic efficiency make it a valuable approach in contemporary agriculture. Ongoing research and technological advancements will further facilitate the adoption of seed weight standardization, contributing to the sustainability and productivity of agricultural systems. This would balance reasonable quality expectations for end-users and economic feasibility for suppliers. The standardization process should be accessible and practical for all stakeholders involved in collecting, producing, and utilizing native seeds.

Regional and local adjustments may be necessary to account for species-specific characteristics and attributes. Implementing standardized weights can promote more sustainable growth in both ecological restoration projects and production industries related to native seed development. Furthermore, the adoption of standardized seed weight can help build trust and confidence among stakeholders in the native seed industry. It can also contribute to the development of certification schemes and quality standards, allowing for better regulation and evaluation of seed suppliers. Weight standardization is just one aspect of native seed quality control, as factors such as seed purity, germination rates, and genetic diversity also play a crucial role in the success of ecological restoration efforts and require further investigation.

Author Contributions

AAA conceptualized and supervised the study, led the project design and coordination, and was the primary author of the manuscript. PR contributed to seed identification and supported data collection efforts. KA assisted in fieldwork and data collection. AAB provided photographic documentation and prepared supplementary materials. All authors reviewed and approved the final version of the manuscript.

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Conflicts of Interest

The authors declare no conflicts of interest.

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