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Row Distance Method Sowing of Forage Kochia, Eastern Saltwort and Winterfat

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Abstract: In this study, we used three native range species of eastern saltwort, winterfat and forage Kochia. These species are extremely adapted to dry lands and have high productivity comparison with other forage species. In order to increase range production in poor, dry and sub dry land in the province of Khorasan (Sabzevar) the seeds of these species naturally were sowed. They were sowed individually on rows and mixed of the two by 2 or 3 species on the alternative rows. The research was carried out statistically in Completely Randomized Block Design (CRBD) as a factorial experiment by two factors. The first factor was row distance of seeding (three levels, 50, 75 and 100 cm distance between each row) and the second was kinds of intercropping methods (seven level of individual seeding by three mentioned species and mixed alternative rows of two by 2 and 3 species together) with four replicates (3×7×4). Number of seed was accounted by the number of bushes were germinated or died in each experimental unit. The results showed that maximum abundant of seed germination of all treatments was occurred from late April to late May. Sowing in the row spaces of 50 cm had highly statistically significant production than the ones of 75 and 100 cm spaces. Also, by comparing relative frequency percentage of germinated seeds and relative germinated died seed revealed that individual sowing seed of *Salsola orientalis* and *Eurotia ceratoides*, by 50 cm row space in Sabzevar region had better result, respectively, because of lowest mortality of plants and highest productivity of biomass.

Key words: Seeding, seed germination, forage Kochia, eastern saltwort, winterfat

INTRODUCTION

Unsuitable yielding from ranges in dry land regions caused to reduce range productivity and increase intensity development of dry lands which in turn extremely decline or degrade of the best palatable and beneficial species in these regions and/or change the types of land use properties, particularly pastures. Therefore, for increasing biomass or reducing the change of rangelands, required to study on range seeding with naturally field preparation for seed plantation of native vegetations. It needs more attention on species having a better palatability for livestock than the other native range species. Which would be helpful to increase the rate of production and rearrangement of grazing lands?

From total production of garden and forages, 41.2% (238617490 forage units) of forage requirement was supplied for over to 17 million animal units of Khorasan province while 21.6% forage unit was deficit (Moghadam, 1978; Organization Management and Programming, 2001), that annually made by over grazing in the pastures area. So, it is required that with different kinds of improvement forage seeding method and planting of brush and seeding, cause to increase range productivity remained forage is supplied by cereals and other crops production.

Kochia prostrata a member of chenopods is a semi-hard brush species having a woody base and many narrow small leaves in above section (Sishkin, 1936). These leaves from spring to winter are green. Seeds ripened in late summer and fall (due to region climate and kind of species) (Shamsutdinov, 1964; Zadbar, 2001; Shu, 2003). In Khorasan province the seeds formed in early September and ripened in early October. Diameter and height of summer cypress (*Kochia prostrata*) related to climate condition which varied from 26 to 37 cm (Keller and Bleak, 1974; Dorikov, 1998), but in a good condition, kind of species and stand so that in research station of Sisab in Bojnord three years old plants raise to one meter height and 200 cm diameter (Zadbar, 2001).

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Previous researches showed that three varieties of species *Kochia villossisima* with and without green branches distributed on sandy soil in semi arid region (Shamsutdinov, 2000). Halophytes is a group of ecological, physiological and biochemical specialized plant species, growing also on the salt substrate conditions, capable to produce green mass and seeds during living period (Aronson, 1985; O'Leary, 1985; Shamsutdinov, 1993; Shamsutdinov *et al*., 2000). Forage kochia has proven to be an adapted, highly palatable forage species for livestock and wildlife. It is competitive with cheatgrass and much more fire resistant (Kettle and Davison, 1995).

Variety of *virescens*, which were distributed in saline soils with light-green leaf and variety of *canescens*, was developed on the rocky soils. Seed germination of *Kochi prostrata* in laboratory, due to ecotype and site conditions were varied and reported from 5-10 to 80-90% (Bagaeva, 1965; Stevens *et al*., 1985). Seed germination of this species in planting at plot and perspective hill conditions on semi-arid climate of Uzbekistan was differed between 0.05 to 17% (Begaeva, 1965; Shamsutdinov, 1964). Production of this species on sandy-rocky clay and sandy soils were 2270, 2240 and 1540 kg ha^{-1} $year^{-1}$, respectively (Shamsutdinov and Shirinskaia, 1969). A seed yield had been harvested from the Kochia plants which the most of their leaves covered with snow (ZoBell *et al*., 2003).

Winterfat (*Eurotia lanata* (Pursh) Moq.) is a native shrub of Khorasan Province. Another species of winterfat (*Eurotia ceratoides* (L.) *C.S.G. Mey.*) is a shrub or semi-shrub species with height of 40-100 cm cushion like and elliptic form or narrow leaf with end of needle like, leaf-stalk is narrow or and long ovate (Esmaili, 1997; McAurthur *et al*., 1996). Laboratory seed germination is 66% but the area with seeded plants restricted to 23%. Average productions of the first year after seeding differ on variability of climate condition and are about 50-80 kg ha^{-1} (Shamsutdinov, 1975). Establishment of winterfat seedlings will be favored by seedbed conditions that protect seedlings from severe and prolonged desiccation and allow fast entry of the radicals less into soil. Hou *et al*. (1999) showed a high portion of hydrated seeds and seedlings can be died when exposed to seedbed desiccation.

Species of *Salsola orientalis* from chenopod family which has low prostrata and woody branches distributed naturally in area of different sites of IR-Iran. Seeds were formed in autumn which yield naturally (Khatir Nameni, 1997). In Sarakhs and Kalat of Khorasan in the middle of November when the seed of Salsola is pruned, the color of seed changes from green to black and dark-yellow (Mukhamedov, 1979). Yield of this species in semi-arid condition of Uzbekistan is 800-1060 kg ha^{-1} $year^{-1}$, which is varied from the first, second and third year after seeding and could grazed until 20 years old by livestock (Shamsutdinov, 1964).

Today, researcher's studies have conducted to find ways for high production of forage. This is why that native species of *Kochia prostrata*, *Eurotia ceratoides* and *Salsola orientalis* were planted in Middle East (Ghazaghestan, Uzbekistan and Turkmenistan) and south of Russia, by seeding method and mixed with tree and shrub species. These species have high forage productivity levels. There for, the objective of this study was to find suitable and adapted species to improve and increase production of poor pastures in dry and sub dry of Khorasan province which resulted to such three species of *Kochia prostrata*, *Eurotia ceratoides* and *Salsola orientalis* planted by single and mixed sowing methods with different row spaces.

MATERIALS AND METHODS

Site description: The area of Khorasan province is about 30 million hectares. Pastures have approximately 12.5 million ha^{-1}, which classified to 2 million ha^{-1} (7.2%) good, with production of 312 kg ha^{-1} dry weight matter, medium pasture 9 million ha^{-1} (32.5%) with 202 kg dry weight ha^{-1}, poor pasture 1.5 million ha^{-1} (5.4%) with 90 kg dry weight ha^{-1} and desert pasture 15.2 million ha^{-1} (54.9%) with 100 kg dry weight ha^{-1} (Table 1) (Organization Management and Programming, 2001).

Total production of natural grazing lands and improved plants of Khorasan province was equal to 4097 million kg dry matter approximately equal to the 2048.5 million forage units (Shariati and Saberi, 1996). Above production was included natural and improved forage by brushing methods of *Atriplex canescence*, *Medicago sativa*, *Agropyron desertrom*, *Agropyron elengatum* and *Artemisia sieberi* in addition to the 668000 plantation of *Haloxylon ammodendron* and *Haloxylon persicum* (Organization Management and Programming, 2001).

The location of this study was dry land in 85 km Northeast of Sabzevar city (average annual precipitation

Table 1: Classification of Khorasan's pastures (Shariati and Saberi, 1996)

Kind of pasture	Area (hectare)	Area (%)	Production	Total production (tone)	Production (%)
Good	2000000	7.2	312	624000	15.2
Moderate	9000000	32.5	202	1818000	44.4
Poor	15000000	5.4	90	135000	3.3
Desert	15200000	54.9	100	1520000	37.1
Total	27700000	100.0		4097000	100.0

Table 2: Precipitation and temperature characteristics at the study sites with 27 years record (1957- 1984)

Variables	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	μ¶
Temperature (°C)													
Maximum mean	7.7	11.4	17.4	23.7	30.7	35.5	37.4	36.1	32.1	24.8	17.5	10.8	23.70
Minimum mean	-20.8	-1.0	4.5	9.9	15.3	19.9	22.0	20.3	15.6	9..5	3.1	-1.4	9.60
Absolute maximum	23.4	24.8	34.0	35.4	41.0	44.0	45.5	43.5	41.2	36.0	29.0	21.0	34.90
Absolute minimum	-19.8	-16.0	-7.0	-2.0	-4.0	8.8	9.5	8.6	3.5	-2.0	-14.0	-19.4	-4.58
Month mean	2.5	5.2	11.1	16.8	22.7	27.7	29.7	28.2	23.9	17.2	10.7	4.7	16.70
Precipitation (mm)¶													
Month	30.6	32.7	35.5	28.0	14.0	1.1	1.7	0.4	0.6	7.1	10.6	27.7	190.00

¶Sum (mm); μ, annual mean

Table 3: Seed and sapling requirements, germination (germ) in laboratory (lab) and nature

Species	Seed weight (1000 g^{-1})	Lab germ (%)	Nature germ (%)	Sapling requirement (number) 50 (cm)	75 (cm)	100 (cm)	Seed requirement (kg ha^{-1}) 50 (cm)	75 (cm)	100 (cm)	Pure (%)
Eurotia	9.6-16	33	23	50000	37500	25000	16.0	12.0	8.0	68
Kochia	0.88-1.92	52	5	50000	37500	25000	6.4	4.4	3.2	60
Salsola	6.39-6.99	40	16	50000	37500	25000	10.0	7.5	5.0	55

200-220 mm, latitude 36° 38' N and longitude: 57° 47' E). Mean monthly temperature was 16.7°C (Table 2). The mean aspect of the site based on field observation and measurement showed lateral direction slops of 2-5% with height of 60 cm fluctuation. Water erosion was moderate and the climate the basis of by the way of Amberget's classification was dry cold (Q = 11.5, m = -3.5). Due to evaluation of lands of the study area (2 soil profile), soil texture in surface horizon was loamy and some small rock in the depth of this horizon. The percentage of small gravel was about 3-5%. Soil had four classes evaluated with limitation of topography. Soil pH in 20-60 cm layer depth was 8.2 and Electrical Conductivity (EC) was 204 (Mm cm^{-2}).

Statistical analysis and experimental design: Analyses were done in Completely Randomized Block Design (CRBD). The mode was as follow:

$$Y_{ijk} = \mu + T_i + R_j + B_k + \epsilon_{ijk}$$

where Y, yield diameter of canopy, height of shrub (cm), dry weighs (g), percentage of dead and life shrubs (as an adaptation criteria) in separate model; μ, general mean; T, first factors; seeding row distances with three levels (50, 75 and 100 cm); R, the second factor, kinds of planting with seven level (pure component of three species, mixed three species two by two and three by three); Indices of I, j and $_k$ showed factor one, two and block (4 replicates), respectively. ϵ_{ijk}, unknown error effects.

Comparison of means was done by Duncan's multiple range method (Yazdi Samadi *et al*., 1998; Stewart *et al*., 2001). Statistical analyses were done in Excel and SAS software programs.

Seed collection and seeding method: Winterfat, forage kochia and saltwort seeds were collected in September 20-30th and November 10-20th at the Bojnord and November 6-16th in 1999 at the Sarakhs pastures, respectively. Cleaned seeds were entered to the natural water to separate of decay and moldy seeds. Seeds were air dried to about 3-6% water content at room temperature for about 30 days and then stored in plastic bags at 15°C. Seeds were sowed after 15 days stored.

Land was cultivated and disked by multiple shone plow. Study area was prepared with 6 m width and 110 m length. Total 21 experimental units (4×5 m) in addition to one meter distance between each experimental unit in every block was established and between blocks 12 m distance for conserving plantation area marginal effects was made. In each experiment, sowing was done by row method. The depth of planting of seed was 0.5-1 cm. The distance between each row was 50, 75 and 100 cm. Weight of one thousands of seed, seed germination and requirement of seeds for *Eurotia*, *Kochia* and *Salsola* showed in Table 3.

RESULTS

Seeds number of *Salsola orientalis* at different times (from primary to the late of seasonal growth) compared with two other species was statistically varied (Fig. 1). Germination of whole species at the early of seasonal growth was greater than the late of seasonal growth but at the month of May was highest due to suitable temperature and precipitation conditions (Fig. 1 and Table 2). Maximum germination of *Eurotia ceratoides* (E), *Kochia prostrata* (K) and *Salsola orientalis* (S) were happened from 15th April to 6th May (Fig. 1).

According to common the local condition, *Salsola orientalis* in individual sowing showed better response to the environmental factor compared to other species and mixed methods, except the best month of seasonal growth of October (Fig. 1). Mean vital seed number in a whole experiment was 27.39, 20.46 and 17.17% for *Salsola orientalis*, *Eurotia ceratoides* and *Kochia prosterata*, respectively (Fig. 2). Months of March, April and May of the seasonal growth had the highest effect because of

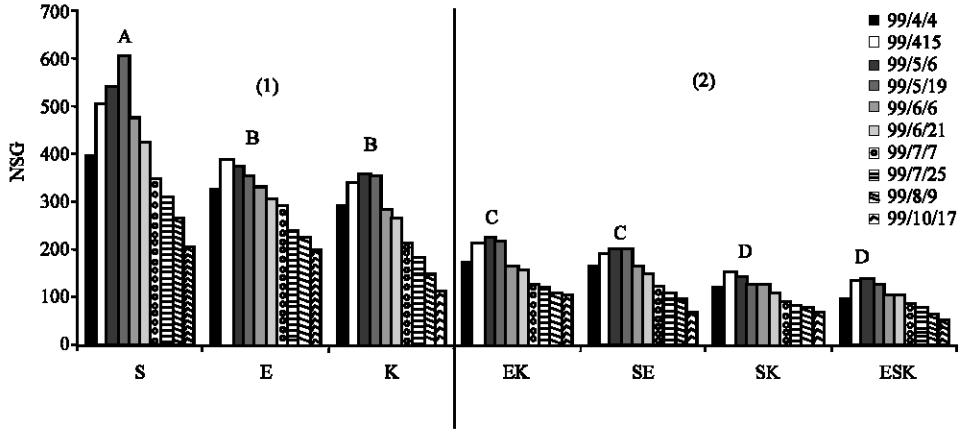

Fig. 1: Number of seeds germination of *Salsola orientalis* (S), *Kochia prostrata* (K) and *Eurotia ceratoides* (E), individual (1) and two by two (EK, SE, SK) or three by three (ESK) mixed (2) species in an alternative rows in Research Station of Sabzevar. Group comparison was down at 5% level

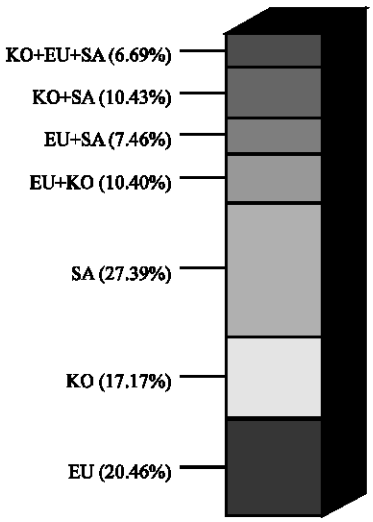

Fig. 2: Medium percentage of natural seed germination of *Salsola orientalis*, *Kochia prosterata* and *Eurotia ceratoides* sowing in individual and mixed two or three seeding in alternative rows

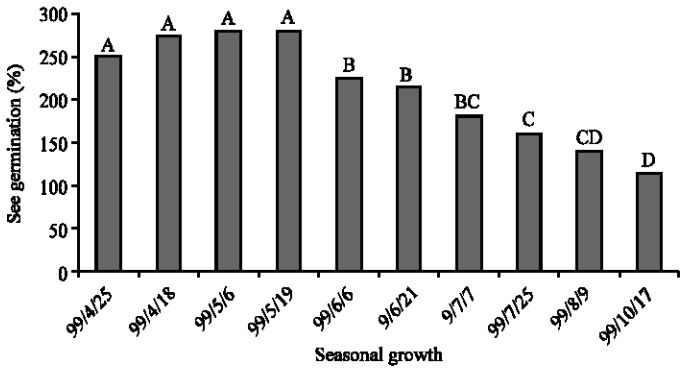

Fig. 3: Medium percentage seed germination component from the first day of germination to the end of seasonal growth

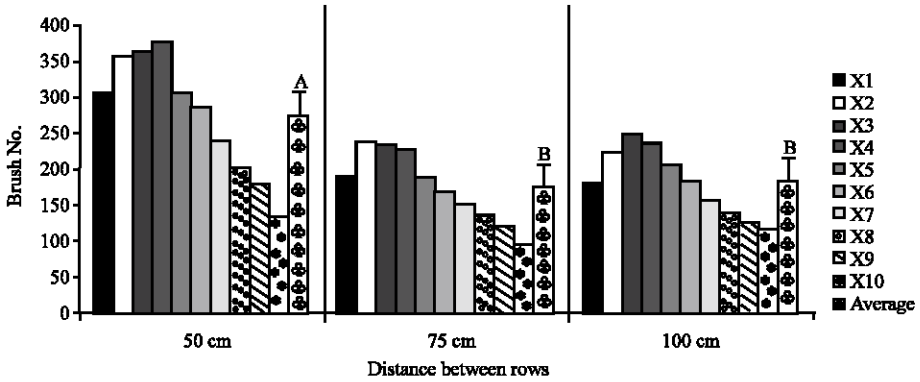

Fig. 4: Percentage medium natural seeds germination of different sowing space of seeds 50, 75 and 100 cm in the different times of seasonal growth (x1 = April 3rd, x2 = April 18th, x3 = May 6th, x4 = May 19th, x5 = June 6th, x6 = June 21st, x7 = July 7th, x8 = July 25th, x9 = August 9th and x10 = October 17th of 1999)

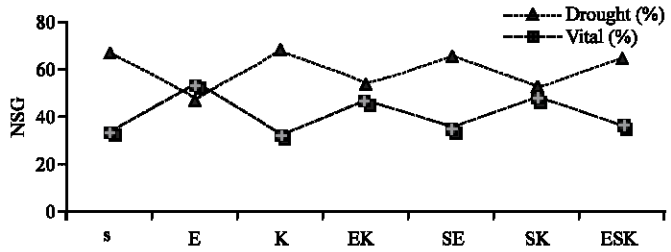

Fig. 5: Relative drought percentage of seed germination (Vital %) and relative drought species (Drought %) in individual and mixed cultivations

suitable climatic factors. Mean seed germination and vitality of all species were happened in early April to late May (Fig. 3).

The growth of whole species in mixed method with 50 cm distance between rows sowing was greatest compared to 75 and 100 cm distances (at 5% level) (Fig. 4). Drier season had more affected to decrease all species germination in individual and mixed sowing methods (Fig. 5). Trends of number of seed germination affected by treatments showed decreasing from individual sowing to the mixed sowing from the first to the last day of growing season. (Fig. 6) Index of the average standardized number of seed vitality revealed that single row sowing of *Salsola*, *Eurotia* and *Kochia* were above and mixed sowing them were below of the index, respectively (Fig. 6, last graph).

DISCUSSION

Frequency of seed germination reduced, when species were sowed in mixed 2 or 3 by 3 at the alternative rows. However, the response of species germination of individual sowing was more suitable than the mixed methods. One of the reasons affect the high dead of plants in dry region was high evapotranspiration of area at the warming growth season (Table 1). However, in this condition *Salsola orientalis* compared with other species was more resistance. High germination and growth of species from March to May was due to the month of high precipitation, suitable temperature and high supply water of the soil compared with the other month of seasonal growth. Direct seed establishment may require some natural disturbances and treatments (Christopher *et al*., 2004) in perennial communities (Harrison *et al*., 2000; McArthur *et al*., 1990, 1974; Stevens and McArthur, 1990) to adapt in arid areas. *Salsola orientalis* dominated in the area and seedling germination were seen at the edge of experimental unit from distributed seeds of this species.

Number and percentage of seed germination of whole species at the early of seasonal growth was greater than the later of season (Fig. 1-3). This is due to favorable spring and water supply of winter at the early growing season in Sabzevar. Comparison result between relative frequency of seed germination and relative drought frequency of seed revealed that ranking of species was

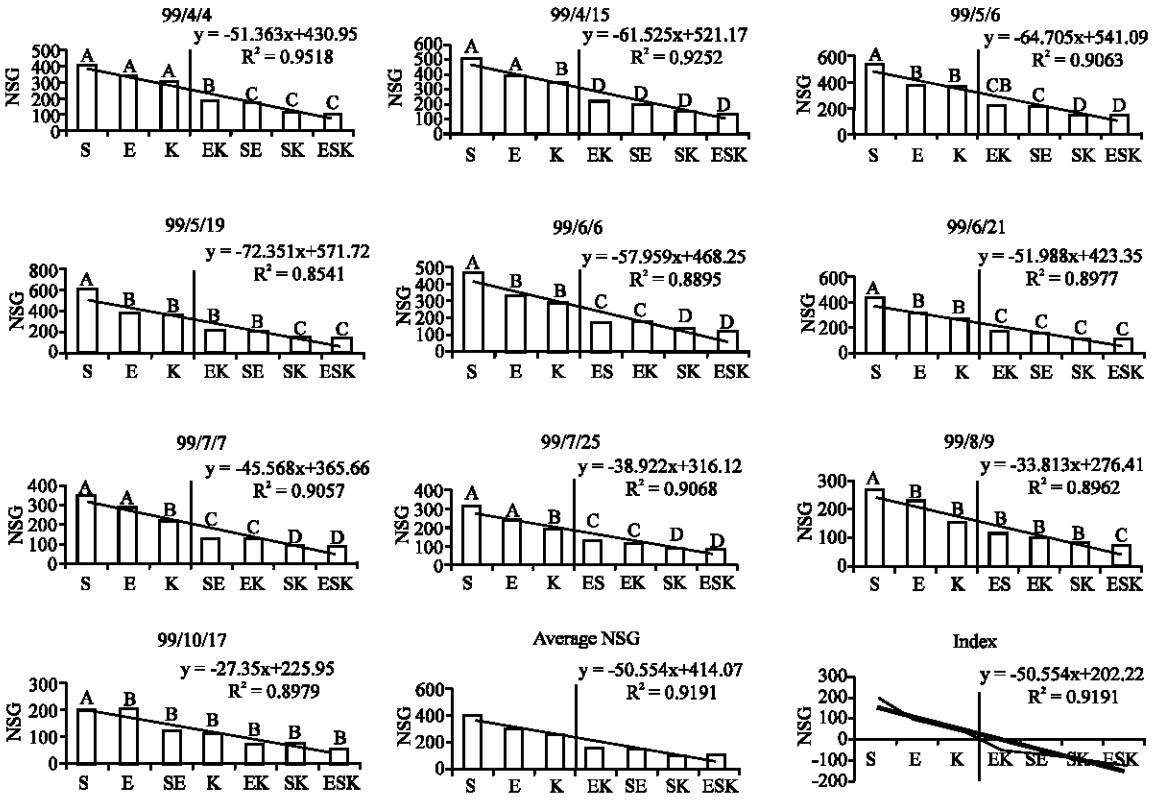

Fig. 6: Number of seed germination (NSG) trends from the first (99/4/4) to the last day (99/10/17) of germination, average and index of NSG in growing season by seven treatments (left side individual and right side mixed). Last figures show regression between NSG and standard of NSG with single to component row sowing, respectively

Salsola orientalis, *Eurotia ceratoides* in individual seed sowing with 50 cm distance between rows (Fig. 4). It is proposed that *Kochia prostrata* grew in all kind of soil such as saline, sandy rocky and poor soils naturally in middle Asia (Shamsutdinov, 1964, 1974; Shamsutdinov and Shirinskaia, 1969; Dorukov, 1998). Research of adaptation, establishment and production in different climatic and edaphically conditions were done and revealed that optimum distance for *Kochia prostrata* var *Karnabkoli* was 60-75 cm in sandy clay soils and 75 cm in desert of Kazakhstan (Bedarev, 1969) but in our study was 50 cm. The results of this study are closed to the ones of Dorikov (1998).

Techniques found to stimulate the germination of the seeds of *Salsola orientalis*, have the best effects when the seeds were first moistened (Nechaeva *et al*., 1977), but seeds are generally tolerant to wet and dry conditions (Hong and Ellis, 1992) and seed decay in germinated seeds increased after hydration-dehydration treatments. This showed that fluctuation of moisture content in air and soil may gradually reduce the percentage of seed germination and viability of seed population (Jorgensen and Davis, 1984). There is positive correlation between plant regeneration in natural areas and frequency and distribution of rain in whole and seasonal growth (Fileh Kesh *et al*., 1999; Zadbar, 2001). In this study larger amount of precipitation at the earlier of growing season more affected to the viability and germination of the seeds.

Viability of mature forage Kochia seeds which remained limited in storage were longer than seed harvested for a long time. Low seed water content is essential to preserving maximum seed viability. Storing seed at a cold temperature is also helpful in maintaining viability (Stewart *et al*., 2001). Three months of storage improved germination significantly in some species. Germination of gray variety of *Kochia* improved immediately from 49.4-52.4% after harvested. while the germination of the green variety of *kochia* seeds increased from 28.1% with no storage to 30.4% with 3 month storage (Baylan, 1972). It seems that if we moisten and store the seeds may cause to taken better results. Seeds of *Kochia prostrata* collected from different ecotypes had varied laboratory viability range from 5-10

to 80-90% (Begaeva, 1965; Bassov, 1961; Begochov, 1940; Chalbash, 1963). Also, seeds sampled from rangelands of flat and semi-hill in arid locations had varied their viability from 5-17% in a field condition (Shamsutdinov, 1964; Shamsutdinov and Shirinskaia, 1969). Not stored seed properly may lose 80-90% viability in less than a year (Moghadam, 1978). In this study, we harvested of seeds ripened and after 15 days stored immediately planted.

Preliminary test for germination characteristics of forage Kochia (Briede and McKell, 1992; Stewart, 1998; Waller *et al*., 1983; Young *et al*., 1981), establishment and competitive attributes (Harrison *et al*., 2000; McArthur *et al*., 1996; Monsen and Turnipseed, 1990; Stevens *et al*., 1985) in some studies have been done. Also, a study demonstrated that forage Kochia is well suited for a variety of soil types on cold-desert rangelands receiving 150-300 mm annual precipitation (Kitchen and Monsen, 2001) is similar to the Sabzevar site in our study. Forage Kochia seed is known to have a short shelf-life, especially under uncontrolled warehouse conditions (Bagaeva, 1965; Baylan, 1972; Keller and Bleak, 1974; Kettle and Davison, 1995; ZoBell *et al*., 2003). In present research, because of the leaves fallen in a hard desert climate condition Salsola is better adapted to the soil and weather condition of Sabzevar.

Interaction between three species of *Kochia*, *prostrata*, *Artemisia herba alba* and *Atriplex canescens* were found to be significant (Nemati, 1977). In mixed sowing we have also the same results, for the reason that the number of seed germination decreased (Fig. 6). A study on stored seed with high water content at a warm temperature revealed that seeds lost 94% viability, while seed stored at a cold temperature lost only 20% viability. Storing seed with low water content, whether in a cold or warm storage temperature caused that preserved seeds, with only 9% viability lost overall. It is imperative to store forage Kochia seed and winterfat with a low water content to ensure preservation of viability (Stevens *et al*, 1985; Stevens and Epps, 1984; Bai *et al*., 1998). It is better that seeding carried out by fresh seeds (Stewart *et al*., 2001), which is in agreement with our work. In dryland condition, number of seed germination in single sowing row distance with individual species had an optimum result.

Forage Kochia is a nutritious perennial that is well adapted to the Khorasan region of the IR-Iran, but it is not better adapted than Salsola. They have tremendous potential advantages for beef producers using them as a nourish material for grazing camel, goat, sheep and cows during the spring, fall and winter. In this line, alternate methods of seed germination should be studied and it is required to repeat them in different times and spaces.

The results of this study showed that species of Kochia isn't recommended to sowing in Sabzevar region in mixed row sowing. In practical and statistical analyses, whole species and intercropping of 50 cm row spaces had highly statistically significant production than the row spaces of 75 and 100 cm. Also, by comparing the percentage of relative frequency of number of seed germination and the percentage of relative died seed revealed that individual seed plantation of *Eurotia ceratoides* and *Salsola orientalis* by 50 cm row space in the region of Sabzevar had better results, respectively.

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