MORPHOLOGICAL AND AGRONOMICAL CHARACTERISTICS OF SOME WILD AND CULTIVATED ISATIS SPECIES

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ABSTRACT

The study evaluated Isatis tinctoria, I. constricta, I. glauca, I. cochlearis, I. aucheri and I. demiriziana during 2002-03 and 2003-04 growing seasons for different agronomic characteristics affecting the percentage of dye in them. The results showed wide variations in the agronomic characteristics of Isatis constricta, Isatis cochlearis, Isatis aucheri, Isatis demiriziana collected from wild; compared to culture Isatis tinctoria and Isatis glauca. I. tinctoria showed early emergence (36 day) compared to other species, and I. glauca was determined as late flowering (512 day) species. Among Isatis species, I. glauca showed the maximum plant height (113.4 cm), stem diameter (10.84 mm) seed yield per plant (103.0 g). Whereas, I. tinctoria produced the largest number of branches per plant (16.8 plant^{-1}) and the maximum number of seeds (17918) per plant.

Keywords: Woad; Isatis species; seed size; seed yield; thousand seed weight

INTRODUCTION

Natural dyes without processing are inconsistent in performance, and require the use of additional chemicals that are potentially hazardous to the environment [9]. Natural dyes are widely used in food and beverage industry and cosmetics [4]. Use of colours and dyes is expected to increase with the passage of time. It is therefore, needed to produce dyes with minimum risk to the consumer. One of the important plant derived dyes is indigo, which is obtained from Indigofera tinctoria, Polygonum tinctorium and Isatis tinctoria, which grow in temperate and tropical regions [10,11].

The most important Indigofera tinctoria is grown in Pakistan and India, the West Indies, Central and South America. Polygonum tinctorum is grown in Japan, woad (I. tinctoria) is grown in Europe. All of these are rich in indican, a by-product of the plants own metabolic process that helps the plant to resist pest attack and discourage grazing animals. Indican has known anti-bacterial, anti fever, anti swelling properties, and is used to treat skin infections in the traditional therapy systems. However, it is more important in dyeing industry [3,8].

Isatis species is biennial, herbaceous shrub belonging to family Cruciferae and is represented by 40 taxa, of which 24 are endemic widely found in Turkey under natural conditions [1,2]. East and South-eastern Anatolia regions represent 31 species and 14 sub species [7].

The production of great amounts of high quality plant material at low costs by the agriculture is an important factor for the revival of natural dyes. It is therefore, necessary to develop modern cultivation techniques for important dye plants, which have gained importance as a new agricultural tool in recent years.

The objective of the study was to determine adaptation ability and morphological and agronomical characteristics of six Isatis species, four of which were gathered from wild under the conditions of Southeast Anatolia.

MATERIALS AND METHODS

Seeds of Isatis tinctoria L. and I. glauca Auch. ex Boiss. were obtained from the Department of Field Crops, Faculty of Agriculture, University of Ankara. I. constricta Davis), I. cochlearis Boiss., I. aucheri Boiss., I. demiriziana Misirdali were collected from wild of South-eastern Anatolia at heights of 1200 (from around the Hazar Lake, lying in between Diyarbakır and Elazıg provinces), 1769 (Nemrut Mountains, Adıyaman province), 2056 (Nemrut Mountains, Adıyaman province) and 1480 m (Ergani, district of Diyarbakır province) respectively above sea level during 2001-2002.

The field experiment was carried out between 2003 and 2004 years at the Department of Field Crops, Faculty of Agriculture, Dicle University, Diyarbakır (latitude 37° 53' N and longitude 40° 16' E, 680 m above sea level), Turkey. Field trial was designed as a collection garden in plots of 1.8 x 4 m. Sowing was done in rows, established by marker at depth of 1-2 cm by hand at the rate of 2-3 seed (hard-shell or fruit) drop in each hole on 03.02.2003. Thinning was done after emergence, leaving one plant in each hole at 4-5 leaves stage. The plots were weeded when needed and irrigated, orderly. Harvesting was done on 02.06.2004 and 29.06.2004, using hand operated scissors. The plants were dried under shade before harvesting seeds by trashing.

As all Isatis species were biennial, all observations were made in the second year, except phenological characteristics. Plant height, stalk diameter, number of branches per plant, number of seeds per plant, seed yield per plant, seed width seed length and thousand seed weight were evaluated from 10 plants per species

Table 1. Phenological observations about *Isatis* species

Phenological observations	*Isatis* species					
	I. tinctoria	*I. constricta*	*I. glauca*	*I. cochlearis*	*I. aucheri*	*I. demiriziana*
Sowing date	03.02.2003	03.02.2003	03.02.2003	03.02.2003	03.02.2003	03.02.2003
Number of days to emergence	36	52	43	52	52	52
Number of days to form stalks forms	412	411	420	401	411	407
Number of days to 50% flowering	429	423	476	419	431	427
Number of days from stalk formation to % 50 flowering	17	12	47	12	20	20
Number of days from sowing to flowering	451	449	444	436	459	428
Number of days to % 50 flowering to harvest	56	62	35	66	54	58
Number of days from sowing to harvest	485	485	512	485	485	485

Table 2. Plant height and plant stem diameter of *Isatis* species

Isatis species	Plant height (cm)			Plant stem diameter (mm)		
	Mean±S dev	Min-max	CV (%)	Mean±S dev	Min-Max	CV (%)
I. tinctoria	91.0 ± 13.93	73.0-112.0	18.46	7.80±0.430	7.3-8.4	5.51
I. constricta	59.0 ± 7.14	50.0-68.0	31.86	10.38±0.719	9.7-11.3	6.93
I. glauca	113.4 ± 5.18	106.0-118.0	4.40	10.84±1.167	8.9-12.0	10.76
I. cochlearis	49.2 ± 8.32	36.0-58.0	22.76	5.76±0.207	5.5-6.00	3.60
I. aucheri	29.8 ± 4.92	24.0-36.0	56.37	6.98±0.820	5.8-8.0	11.74
I. demiriziana	46.8 ± 4.76	40.0-53.0	21.79	6.72±0.581	5.9-7.4	8.65

Table 3. Number of main branches per plant and number of seeds per plant of *Isatis* species

Isatis species	Number of main branches (pieces plant^{-1})			Number of seeds per plant (pieces plant^{-1})		
	Mean±S dev	Min-Max	CV (%)	Mean±S dev	Min-Max	CV (%)
I. tinctoria	16.8 ±7.56	8-26	45.00	17918±4168	13280-22812	23.26
I. constricta	18.8±9.73	11-35	51.75	6454±1473	4385-8318	22.82
I. glauca	5.0 ±1.581	3-7	31.60	10182±2304	7428-13494	22.63
I. cochlearis	11.2 ±4.71	7-19	42.05	3177±1020	1918-4729	32.11
I. aucheri	16.8 ±7.56	9-32	54.11	5221±2361	2382-8316	45.22
I. demiriziana	10.2 ±2.17	7-12	21.27	7944±2361	5423-11281	29.56

Table 4. Seed yield per plant and seed width of *Isatis* species

Isatis species	Seed yield per plant (pieces plant^{-1})			Seed width (mm)		
	Mean±S dev	Min-Max	CV (%)	Mean±S dev	Min-Max	CV (%)
I. tinctoria	87.8±13.08	77-110	14.89	4.03±0.564	3.65-5.03	13.98
I. constricta	33.6±11.67	22-53	34.73	2.48±0.409	2.11-3.11	16.47
I. glauca	103.0±29.5	75-140	28.64	6.53±0.410	5.90-7.11	6.58
I. cochlearis	12.2±4.2	8-17.4	34.42	2.03±0.155	1.90-2.28	7.62
I. aucheri	50.0±15.92	28-71	31.84	3.42±0.843	2.61-4.54	24.63
I. demiriziana	17.8±6.83	11-27	38.37	4.42±0.361	3.95-4.89	8.17

Table 5. Seed length and thousand seed weight of *Isatis* species

Isatis species	Seed length (mm)			Thousand seed weight (g)		
	Mean±SEM	Min-Max	CV (%)	Mean±SEM	Min-Max	CV (%)
I. tinctoria	15.83±0.903	14.6-17.2	5.70	5.30±0.316	5.0-5.8	5.96
I. constricta	13.17±0.992	11.6-14.2	7.53	5.80±0.332	5.4-6.3	5.72
I. glauca	18.04±3.14	14.1-21.9	17.41	11.00±0.406	10.4-11.5	3.6
I. cochlearis	7.61±0.371	7.2-8.2	4.87	3.60±0.418	3.1-4.2	11.6
I. aucheri	9.76±1.720	8.4-12.6	17.61	11.2±0.255	10.9-11.5	2.27
I. demiriziana	8.52±0.587	7.5-8.9	6.88	6.60±0.235	6.3-6.8	3.56

and analysed statistically, using MINITAB computer program. Standard deviation (S dev), minimum and maximum values and variation coefficients (CV) of each species were also determined.

RESULTS AND DISCUSSION

Phenologic values of Isatis species are given in Table 1. Among all Isatis species, I. tinctoria showed early emergence. The number of days to emerge for I. tinctoria was 36 followed by I. glauca with 43 days and the others with 52 days, respectively. Flowering, stalking and maturity of wild species showed inconsistent behaviour. I. glauca took 47 days to flower. I. demiriziana, I. cochlearis, I. constricta and I. aucheri are domestic plants of Southeast Anatolia, and they stalked earlier than other species. The harvest of Isatis species varied between 485 to 512 days. Harvesting of I. glauca was done during last week of June. As the wild plants show irregular behaviour, it is therefore necessary that they should be selected according to the breeding aims.

Plant height (Table 2) of I. tinctoria and I. glauca showed range of 73.0-112.0 cm and 106.0-118.0 cm respectively with variation coefficients (of these species) lower than those of other species. The minimum plant height and high CV values were recorded from I. aucheri. Similar findings were recorded by Hurry [5] and Kizil [6] for I. tinctoria. Plant height is changeable character. Ecological variations such as altitude, location, light and temperature could affect the agronomical observations. Also, these differentiations might be due to origin and genetics of plants. Plant height is important consideration for mechanical harvesting. Moreover, positive correlation was observed between plant height and number of branches per plant, which affects number of seeds per plant as well. Moreover, plant height contributes to number of branches. More branches per plant directly influences the number of fruits/seeds per plant, an important agronomic characteristic. Therefore, taller plants with more fruits/seeds per plant is an important characteristic which should be given due importance during breeding of Isatis species.

Plant stem diameter (Table 2) of Isatis species varied between 5.76 and 10.84 mm. I. cochlearis, and I. tinctoria had thin stems diameter. I. glauca had thicker stems compared to others. Variation coefficient of I. cochlearis and I. tinctoria was found as 3.60 and 5.51, which did not show much variation. Plant stem diameter is important, since it provides resistance against lodging due to wind or rains. Especially during seed setting, fast blowing winds or rains could result in the breaking of seed bearing branches or stems affecting the seed yield of plants. The thicker the stems provide more resistance against lodging. Thin stemmed plants are very prone to lodging or stem breaks due to wind or rain especially when the plants grow faster under the influence of high nitrogen fertilisation. Therefore, plants with thick stems should be given considerations during breeding.

Mean numbers of branch of Isatis species (Table 3) were very inconsistent. The minimum brunches were obtained from I. glauca and the maximum brunches were obtained from I. constricta. I. glauca and I. tinctoria did not show wild character compared to other species like fruit dropping and irregular maturity.

The number of seeds per plant varied between 1918-22812 pieces plant^{-1}. Number of seeds per plant is an important character for seed yield. The maximum numbers of seeds per plant were obtained from I. glauca and I. tinctoria, respectively. Species collected from wild showed wild characters, including seed drop and irregular maturity. I. tinctoria was indicated more homogenous than the other species in respect of number of seeds per plant.

An increase in seed length and width of Isatis species also contributed to increase in thousand seed weight of the respective plants. Variable maturity of seeds also affected the seed size even with in the same species. The minimum seed width was recorded in I. constricta and I. cochlearis. The maximum seed width was determined from I. glauca (Table 4). Seed length of species varied between 7.2-21.9 mm. Similar results were recorded by Hurry [5] and Kizil [6] for I. tinctoria. The maximum seed length recorded from I. glauca, I. tinctoria and I. constricta was 18.04, 15.83 and 13.17 mm, respectively. Similar results were reported by Davis [1], Misirdali et al. [7] and Kizil [6].

Thousand seed weight of each species showed considerable variations among species. The seeds of I. aucheri and I. glauca were larger than other species. In addition, variation coefficient of species varied between 2.27-11.6, which showed that thousand seed weight is an acceptable limit for cultivation.

Suitable growing conditions and techniques could affect some plant properties, such as plant height, plant stem diameter thickness, number of branches etc. Large variation is an important character that helps breeder in selection for desirable characteristics.

CONCLUSION

All Isatis species showed well adaptation ability and showed wide variations in terms of observed characteristics. It was observed that in terms of plant height I. glauca (113.4 cm) and I. tinctoria (91.0 cm) gave the highest values, and I aucheri showed high variation.

Plant stem diameter of species was close to each other except I. glauca (10.84 mm) and I. costricta (10.38 cm); the maximum numbers of branches were obtained from I. constricta (18.8 pieces), I. tinctoria (16.8) and I. aucheri (16.8 pieces), respectively. I. glauca (103.0 g) and I. tinctoria (87.8 g) were more productive than others in terms of seed yield per plant. In addition according to seed size, it was observed that I. glauca had large seed width and length. Thousand seed weight of species varied between 3.6-11.2 g. It was felt necessary that wild Isatis species should be selected as population and multiplied as lines for breeding according to breeding aims (biomass yield, dye content etc).

In conclusion; most Isatis species are wild plant species, which must be cultivated and adapted under field conditions as their biomass yield per unit area are high or very high compared to their dye contents. Further studies are needed to determine high dye content of Isatis species under different growing conditions.

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