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Studies on leaf yield and association analysis in underutilized and cultivated *Allium* species

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Abstract
A field experiment was carried out at ICAR-Directorate of Onion and Garlic Research, Rajgurunagar, Pune, Maharashtra during Rabi season of 2017-18 to study the yield attributes of underutilized and cultivated *Allium* species. All the forty genotypes were laid out in RBD with three replications maintaining a spacing of 25x20 cm. Variation in respect of yield per cutting has been observed. Total yield varied from 0.48 t/ha to 19.80 t/ha. The maximum leaf yield (19.80 t/ha) was obtained in *Allium tuberosum* kazakhistan All-1587. It was at par with *Allium tuberosum* CGN-16418(Flowering) (18.20 t/ha), *Allium tuberosum* Rottl Ex-spr kuchaai CGN-16373 (17.17t/ha) and *Allium tuberosum* EC-607483 (14.97t/ha). Minimum yield was found in the *Alliummacranthum*NMK-3216 (0.48t/ha). Correlation analysis manifested total yield had significant and positive correlation with sulphur. Plant height was highly significantly and positively correlated with leaf length, leaf width, and total yield. Number of leaf per plant had significant positive correlation with phenol, flavanoids, and pyruvic acid. Positive and significant correlation between desirable characters is beneficial which helps in simultaneous improvement of both the characters.

Keywords: Underutilized, cultivated and *Allium* species

Introduction
The genus *Allium* includes hundreds of species those are cultivated worldwide for consumption purpose. Onion, garlic, leek, shallot, chive etc. are important edible species cultivated for fresh consumption, cooking and as processed products. They are known to have great medicinal properties, which are used for curing variety of human disorders. Among the oldest cultivated vegetables, *Allium* is the most important genus of the Alliaceae family. Indian gene centre is fairly rich in wild *Allium* species (about 30) mostly confined to Himalayas (Negi and Pant 1992) [9]. *Alliums* are used in Western Himalaya as spice/condiment in curries, as vegetable and bulbs for seasoning salads. Field surveys and research studies have ensured utilization for edible purposes of wild *Allium* species in Garhwal and Kumaon regions of Himalaya (Negi and Gaur, 1991) [10]. Generally, all plant parts are used for human consumption as raw or as cooked vegetable.Onion & garlic are cultivated all over the world and used as a food item, generally utilized as cooked or as vegetable. Onion and garlic are highly susceptible for drought, water logging and the most of the diseases and pests, which affect the yield and causes price fluctuations. Onion price is affected mainly during *Kharif* season due to excess water logging. The demand of onion in the market increases during *Kharif* season and causes price rise. Underutilized *Allium* species are rich in nutrients and foliage have flavour similar to onion such as *Allium tuberosum, Allium anglosum, Allium chinense and Allium macaranthum*. These underutilized *Allium* species can be good alternative to onion and garlic. Wild *Alliums* can be used as fresh or processed product.These species with great utilization could provide different biochemical compounds to human diet. No such studies were conducted in underutilized *Alliums*. Thus keeping in view of all these points present work has been conducts.

Material and Method
Plant material and field site description
The study was conducted with thirty seven genotype of four species of underutilised

Alliums viz. *Allium angulosum*, *Allium chinensis*, *Allium macaranthum*, *Allium tuberosum* which were collected from Austria, Netherlandand different parts of India along with three onion (*Allium cepa*) varieties *viz*. Bhima Kiran, Bhima Shakti and Bhima Shweta from ICAR- Directorate of Onion & Garlic Research (DOGR), Pune Maharashtra. The experiment was laid out in RBD in three replication at ICAR-DOGR during rabi season of 2017-18**.** A total of 40 genotypes were planted in three replicates, each in a plot of 1.0×2.0 m with distance of 25 × 20 cm for each plant. The recommended agronomic practices were adopted for raising a good crop. The analysis of variance was carried out as per method of Panse and Sukhatme (1967) [11].

Morphological parameters studied

A total of 9 qualitative and 9 quantitative morphological traits were investigated in their natural conditions. Five plants were randomly selected from each plot to record the data. Observation son leaf cuttings were recorded at 15 days interval after 60 days after planting at four stages. Quantitative traits were analyzed including plant height (cm), number of leaves per plant, number of leaves per tiller, number of tillers per hill, leaf length (cm),leaf width (cm), girth of tiller (mm) pseudo stem length (cm) and total leaf yield (t/ha). Observations were recorded for all traits in three replicates for each entry. For biochemical traits (phenol, ascorbic acid, flavanoids, pyruvic acid, total sugar and reducing sugarcontent), fresh leaf samples were collected after second cutting and stored at -80ºC for further analysis. Fresh foliage yield per cutting and total soluble solids (TSS) were recorded after harvesting**.** Correlation coefficient was estimated as per method given by Miller *et al*. (1958).

The degree of association between independent and dependent variables was first suggested by Galton (1888) [3] its theory was developed by Pearson (1904) [12] and their mathematical utilization at phenotypic, genotypic and environmental levels as described by Searle (1961) [13] were used.

Result and Discussion

Analysis of Variance

The analysis of variance of all the characters under study revealed that mean sum of squares due to genotypes was highly significant for all the characters under study (Table 1 and 2). This is an indication of existence of sufficient variability among the genotypes for leaf yield and its component traits. Significant mean sum of squares due to leaf yield and attributing characters revealed existence of considerable variability in material studied for improvement of various traits. These findings are in general agreement with the findings of Jafari *et al*., 2017 [5] in *Alliums*.

Table 1: Analysis of variance for nine morphological characters under studyin underutilized and cultivated *Alliums.*

Mean Sum of Square			
Characters	**Replication**	**Genotypes**	**Error**
df=2	**df=39**	**df=78**	
Plant height	38.54	153.79**	2.17
No of tiller per hill	22.49	10.93**	0.71
No of leaves per tiller	3.08	10.9**	0.59
No of leaves per plant	1109.5	201.3**	28.47
Leaf length	93.67	176.24**	4.3
Leaf width	0.002	0.57**	0.03
Girth of tiller	1.32	58.92**	0.53
pseudo stem length	0.45	17.2**	0.31
Total leaf yield	108.2	100.07	** 10.36

*, ** are significant at 5% and 1% levels of significance, respectively.

Table 2: Analysis of variance for biochemical characters under study in underutilized and cultivated *Alliums*.

Mean Sum of Square			
Characters	**Replication**	**Genotypes**	**Error**
df=2	**df=39**	**df=78**	
Phenol	0.33	12.88**	0.06
Flavonoids	0.32	0.90**	0.09
Pyruvic acid	72.73	473.4**	15.89
Ascorbic acid	5.83	13.10*	3.74
Total sugar	76.57	807.7**	58.10
Reducing sugar	76.79	795.2**	57.99
Non reducing sugar	1.70	361.57**	16.53
Allicin	0.15	9.77**	0.12

*, ** are significant at 5% and 1% levels of significance respectively.

Yield of leaf cuttings at different stages (t/ha)

From the data presented in form of leaf yield per cutting presented in Table-3. It is apparent that in first cutting yield varied from 0.22 t/hato 8.59t/ha. Bhima Kiran produced significantly the highest yield (8.59 t/ha) followed by Bhima Shweta (7.21 t/ha), Bhima Shakti (7.02t/ha) and *Allium tuberosum* kazakhistan All-1587 (5.02 t/ha) while, the lowest yield was obtained in *Allium macranthum* NMK-3216 (0.22 t/ha) which was at par with *Allium macranthum* NMK-3243 (0.24 t/ha), *Allium macranthum* NMK-3244 (0.29 t/ha), *Allium macranthum* NMK-3233 (0.30 t/ha), and *Allium macranthum* NMK-3227 (0.31 t/ha).

Leaf yield in second cutting yield varied from0.00t/ha to5.56t/ha. *Allium tuberosum* kazakhistan All-1587produced significantly the highest yield (5.56 t/ha) followed by *Allium tuberosum* GN-16418(Flowering)(4.65t/ha),*Allium tuberosum* Rottl Ex-spr kuchaai CGN-16373 (4.57 t/ha),*Allium tuberosum*EC-607483 (3.99 t/ha) and the lowest yield was obtained in *Allium macranthum* NMK-3216 (0.17 t/ha), while Bhima Shakti, Bhima Kiran and Bhima Shweta do not produce any leaf after first cutting.

In third cutting leaf yield varied from 0.00 t/ha to 4.12 t/ha .*Allium tuberosum* kazakhistan All-1587 produced significantly the highest yield (4.12 t/ha) followed by *Allium tuberosum* Rottl Ex-spr kuchaai CGN-16373 (3.99 t/ha), *Allium tuberosum* EC-607483 (3.33 t/ha) and the lowest yield was obtained in *Allium macranthum*NMK-3243 (0.09 t/ha), while Bhima Shakti, Bhima Kiran and Bhima Shweta do not produce any leaf.

It was found that yield varied from 0.00 t/ha to 5.09 t/ha in fourth cutting. *Allium tuberosum* kazakhistan All-1587 produced significantly the highest yield (5.09 t/ha) followed by *Allium tuberosum* CGN-16418(Flowering) (4.91 t/ha), *Allium tuberosum* Rottl Ex-spr kuchaai CGN-16373 (4.69 t/ha), *Allium tuberosum* EC- (4.10 t/ha) and the lowest yield was obtained in *Allium chinense* NG-3165 (0.18 t/ha) while, growth of *Allium macaranthum* species was stunted and that may be due to environmental factors. In *Allium cepa* (Bhima Shakti, Bhima Kiran and Bhima Shweta) there was no leaf formation.

Total yield (t/ha)

It is evident from Table 3 that variation in respect of yield per cutting. Total yield varied from 0.48 t/ha to 19.80 t/ha. The maximum leaf yield (19.80 t/ha) was obtained in *Allium tuberosum* kazakhistan All-1587. It was at par with *Allium*

tuberosum CGN-16418(Flowering) (18.20 t/ha), *Allium tuberosum* Rottl Ex-spr kuchaai CGN-16373 (17.17t/ha), *Allium tuberosum* EC-607483 (14.97t/ha). However minimum yield was found in the *Allium macranthum* NMK-3216 (0.48t/ha).

These results fall in line with those of Adamczewka *et al*. (2010) worked on yielding and biological value of garlic chives (*Allium tuberosum* Rottl. EX spreng). They reported that the yield of leaves in 2013 was on average 32.8% higher than the leaf yield in 2011 and 2012 which may be a consequence of moderate temperature and higher total rainfall in the first half of the plant growing period in 2013.

Mahajan *et al*. (2016) [8] reported *Allium* tuberosum line All-1587 and *Allium tuberosum* Rott. Kuichai line CGN- 16373 recorded uniform yield in all season and thus are suitable for year round cultivation and could be substitute to onion and garlic with added nutrition.

Table 3: Mean performance of underutilized and cultivated *Alliums*for yield traits under study

Entries	Leaf yield in different cuttings (t/ha)				
	Ist	IInd	IIIrd	IVth	Total yield
A. angulosum EC-328486	3.90	2.71	2.29	1.69	10.5
A.chinense NG-3165	0.33	0.30	0.27	0.18	1.07
A.chinense NMK-3247	0.72	0.68	0.75	0.52	2.66
A.chinense NMK-3249	0.74	0.86	0.83	0.59	3.01
*A.macranthum*NMK-3216	0.22	0.17	0.09	0.00	0.48
*A.macranthum*NMK-3227	0.31	0.22	0.12	0.00	0.66
*A.macranthum*NMK-3229	0.35	0.30	0.14	0.00	0.79
*A.macranthum*NMK-3232	0.37	0.32	0.21	0.00	0.89
*A.macranthum*NMK-3233	0.30	0.31	0.14	0.00	0.75
*A.macranthum*NMK-3236	0.41	0.38	0.15	0.00	0.94
*A.macranthum*NMK-3237	0.40	0.26	0.14	0.00	0.80
*A.macranthum*NMK-3238	0.40	0.37	0.17	0.00	0.93
*A.macranthum*NMK-3240	0.31	0.27	0.13	0.00	0.71
*A.macranthum*NMK-3242	0.42	0.34	0.11	0.00	0.86
*A.macranthum*NMK-3243	0.24	0.23	0.09	0.00	0.56
*A.macranthum*NMK-3244	0.29	0.20	0.14	0.00	0.64
*A.macranthum*NMK-3245	0.41	0.38	0.18	0.00	0.95
*A.macranthum*NMK-3246	0.42	0.38	0.18	0.00	0.97
*A.*tuberosumBawang kuchaai-CGN-15749	2.74	2.75	2.52	3.09	11.0
*A.*tuberosum CGN-16418(Flowering)	4.67	4.65	3.99	4.91	18.2
*A.*tuberosum CGN-16418(Non flowering)	3.51	3.74	3.09	3.96	14.3
*A.*tuberosum EC-607483	3.56	3.99	3.33	4.10	14.9
*A.*tuberosumkazakhistan All-1587	5.02	5.56	4.12	5.09	19.8
*A.*tuberosum MKG-84	2.33	2.69	2.56	2.69	10.2
*A.*tuberosum MKG-85	0.81	1.16	1.28	1.20	4.45
*A.*tuberosum MKG-88	1.52	2.27	2.49	2.78	9.06
*A.*tuberosum NG-3183	3.75	3.71	3.19	3.98	14.6
*A.*tuberosum NMK-3207	1.38	2.10	2.14	2.19	7.80
*A.*tuberosum NMK-3211	2.36	2.39	2.34	2.61	9.69
*A.*tuberosum NMK-3214(Non Flowering)	1.80	1.97	1.98	2.48	8.23
*A.*tuberosum NMK-3228	2.32	2.68	2.49	2.87	10.3
*A.*tuberosum NMK-3229	1.99	2.16	1.92	2.17	8.23
*A.*tuberosum NMK-3231	1.38	2.00	2.14	2.39	7.91
*A.*tuberosumRottl Ex-sprkuchaai CGN-16373	3.92	4.57	3.99	4.69	17.1
*A.*tuberosumRottl Ex-sprkuchaai CGN-16412(F)	0.74	0.61	0.93	0.85	3.13
*A.*tuberosumzimmu	1.93	2.00	1.99	2.16	8.07
*A.*tuerosum NMK-3219	3.36	3.20	2.80	3.94	13.3
A. cepa (Bhima Kiran	8.59	0.00	0.00	0.00	8.59
*A. cepa (*Bhima Shakti)	7.02	0.00	0.00	0.00	7.02
*A. cepa (*Bhīma Shweta)	7.21	0.00	0.00	0.00	7.21
Species wise performance					
*A.*angulosum	3.90	2.71	2.29	1.69	10.5
*A.*chinense	0.39	0.61	0.61	0.43	2.24
*A.*macaranthum	0.34	0.29	0.14	0.00	0.78
*A.*tuberosum	2.58	2.85	2.59	3.06	11.0
A. cepa	7.60	0.00	0.00	0.00	7.60
C.D. 5%	1.47	1.26	1.96	1.48	4.25
C.V.	27.36	25.75	29.85	28.58	31.96
S.E.	0.49	0.24	0.28	0.47	0.86

Association analysis for yield and different morphological & biochemical traits

Correlation coefficient was estimated between yield and its attributes at genotypic and phenotypic levels to know the inter-relationship among the characters and is presented in Table 4. Correlation analysis in wild *Alliums* revealed that plant height was highly significantly and positively correlated with leaf length (0.86), leaf width (0.718), and total yield

(0.45). It had significant negative association with No. of leaf per plant (-0.382), pyruvic acid (-0.24), TSS (-0.329) and allicin (-0.293). It had high significant but negative association with phenol (-0.578) and flavonoids content (-0.506).

Number of leaf per plant showed significantly negative correlation with leaf width (-0.475) and with leaf length (-0.276) also.It had significant positive association with phenol (0.279), flavanoids (0.273), and pyruvic acid (0.177).

Leaf length revealed high significant positive correlation with leaf width (0.764) and total yield (0.636).It had high significant negative correlation with phenol (-0.717), flavanoids (-0.492), TSS (-0.518), allicin (-0.333). Whereas, it had significant but negative correlation with pyruvic acid (-0.285). Leaf width showed significant positive association with total yield (0.427).Whereas it was found highly significant negative correlation with phenol (-0.647), flavonoids (-0.386), TSS (-0.437). It had significant negative correlation with pyruvic acid (-0.21), allicin (-0.207).

Total leaf yield from all the four cuttings showed high significant negative association with phenol (-0.629), TSS (-0.688), allicin (-0.312) and significant negative correlation with pyruvic acid (-0.267). Whereas, it had significant positive correlation with sulphur content (0.371).

Phenol showed significant positive correlation with TSS (0.517), allicin (0.332), flavonoids (0.323) and pyruvic acid (0.3) and significant negative correlation with sulphur (-0.235).

Flavonoids revealed significant positive correlation with pyruvic acid (0.282). Pyruvic acid showed significant positive correlation with TSS (0.342) whereas it showed significant negative correlation with sulphur (-0.233). TSS showed significant positive correlation with allicin (0.291) and significant negative correlation with sulphur (-0.412).

Similar results have been reported by Shri Dhar (2002) [15] and Agrawal and Tiwari (2009) [2] in garlic.These results were corroborative with earlier findings of Kalloo *et al*. (1982) [6] for plant height, bulb weight, bulb diameter, clove weight; Lokhande and Pawar (1988) [7] for plant height, bulb weight and number of cloves per bulb; Sharma *et al*. (1998) [14] for bulb weight, bulb diameter and plant height in garlic.

Table 4: Association analysis for yield and different morphological & biochemical traits under study

	Plant height (cm)	No of leaf per plant	Leaf length (cm)	Leaf width (cm)	Total yield (t/ha)	Phenol (mg/g)	Flavanoids (mg/g)	Pyruvic acid (µg/g)	Ascorbic acid (mg/g)	TSS (%)	Sulphur (%)	Allicin (%)
Plant height (cm)	1	-0.382*	0.86**	0.718**	0.45**	-0.578**	-0.506**	-0.24*	-0.069	-0.329*	-0.03	-0.293*
No of leaf/plant		1	-0.276*	-0.475**	-0.083	0.279*	0.273*	0.177*	0.141	0.028	-0.027	-0.043
Leaf length (cm)			1	0.764**	0.636**	-0.717**	-0.492**	-0.285*	0.056	-0.518**	0.192	-0.333**
Leaf width (cm)				1	0.427**	-0.647**	-0.386**	-0.21*	-0.009	-0.437**	0.12	-0.207*
Total yield (t/ha)					1	-0.629**	-0.11	-0.267*	0.022	-0.688**	0.371*	-0.312**
Phenol (mg/g)						1	0.323*	0.3*	-0.078	0.517**	-0.235*	0.332**
Flavanoids (mg/g)							1	0.282*	-0.13	-0.051	0.06	0.122
Pyruvic acid (µg/g)								1	-0.133	0.342*	-0.233*	0.14
Ascorbic acid (mg/g)									1	0.145	0.088	-0.037
TSS (%)										1	-0.412*	0.291*
Sulphur (%)											1	-0.184
Allicin (%)												1

*, ** Denotes significant at 5% and 1% levels of significance, respectively

Conclusion

In this study, underutilized *Allium* species along with cultivated varieties were evaluated. The maximum leaf yield (19.80 t/ha) was obtained in *Allium tuberosum* kazakhistan All-1587. It was at par with *Allium tuberosum* CGN-16418(Flowering) (18.20 t/ha), *Allium tuberosum* Rottl Ex-sprkuchaai CGN-16373 (17.17t/ha), *Allium tuberosum* EC-607483 (14.97t/ha). Minimum yield was found in the *Alliummacranthum*NMK-3216 (0.48t/ha). *Allium cepa* (Bhima Shakti, Bhima Kiran and Bhima Shweta) do not produce leaf yieldin second, third and fourth cutting.Correlation analysis manifested total yield hadsignificant and positive correlation with sulphur. Plant height was highly significantly and positively correlated with leaf length, leaf width, and total yield. Number of leaf per plant had significant positive correlation with phenol, flavanoids, and pyruvic acid. Positive and significant correlation between desirable characters is beneficial which helps in simultaneous improvement of both the characters.

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