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Yield variation and aphid scoring of different cowpea (*Vigna unguiculata*) genotypes across the environment

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Abstract

Producing improved legume forages may contribute to the improvement of the quality supply of the livestock feeding system in Ethiopia. Dry matter and seed yield evaluation and aphid infestation scoring of cowpea genotypes were undertaken for three production seasons (2018-2019). The treatment of five cowpea accessions (ILRI_9333, ILRI_9334, ILRI_11114, ILRI_12668, and ILRI_12713) and one recently released variety as a standard check (Temesgen) at three locations (Arba Minch Agricultural Research Center (AMARC), Bonga Agricultural Research Center (BARC) and Hawassa Agricultural Research Center (HARC) was laid out at the field in a randomized complete block design with three replications. Growth, yield, and aphid scoring parameters were collected to present the comparison of genotypes. Vine length and branch number of ILRI_3334 followed by ILRI_12173 was significantly taller in all locations than the standard check and other genotypes in the test. Dry matter yield production was significantly ($P<0.05$) higher for ILRI_12713 (8.87 t/ha) followed by ILRI_9334 (8.44 t/ha) and ILRI_11114 (8.4 t/ha) while in seed yield variety ILRI_11114>ILRI_12668>ILRI_12713 than Temegen and others in the experiment. Aphid infestation in the cowpea field significantly influenced dry matter yield and seed yield. Dry matter yield was positively correlated with branch number and vine length. Seed yield was positively and significantly ($P= 0.047$ and 0.015) correlated with seed per pod and harvest index. Hence, ILRI_12713, ILRI_9334, and ILRI_11114 are to be considered for further cowpea breeding programs for dry matter and seed yield under aphid-infested conditions. Quality of the materials under irrigated and other agronomic conditions might be the future assignment.

Keywords: Dry Matter; Seed Yield; Vigna Unguiculata; Vine Length

1. Introduction

The forage production trend of smallholder farmers in Ethiopia has been decreasing from time to time and could not supply sufficient feed for the livestock system (1). Ethiopian forage production system predominantly depends on green fodder/grazing 54.54%, crop residue 31.13%, improved forage 0.57%, hay 7.35%, byproducts 2.03%, and other sources 4.37% (1). Cowpea is a multipurpose (food and feed) dicotyledonous plant belonging to the family Fabaceae which is widely grown in lowlands and midland regions of Africa as a sole crop as well intercropped with cereals (2).

Cowpea is the most extensively grown, distributed, and traded food and feed crop consumed more than 50%, of because of its considerable nutritional and health value to man and livestock (3). Grain yield and dry matter yield significantly vary among different varieties of *Vigna unguiculata* (2). The biomass yield of cowpea on a dry matter basis averaged 4.3 t/ha with the grain yield of 2.22 t/ha (4) which can sustain more than 550 lactating Boran goats at their highest milk yield. The highest dry matter yield of 10.56 t/ha (5) to 16.1 t/ha (6) was reported for some accessions of cowpea in Ethiopia. The yield potential of cowpea dry matter was ranging from 18-24 t/ha with seed yield of 1.1-4.9 t/ha in the

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ADDIN CSL_CITATION {"citationItems":[{"id":"ITEM-1","itemData":{"abstract":"Investigations were conducted with an objective to identify alternative crops, especially legumes with low water requirement to replace the water intensive conventional species in forage production systems in the United Arab Emirates (UAE). Thus, the performance of 23 accession of cowpea (Vigna unguiculata) and 10 accessions of guar (Cyamopsis tetragonoloba) was evaluated over a growing period of 120 days during summer in 2009. In cowpea, the dry matter yield, averaged over the accessions was 18.1 t ha-1 with accession TVu 9480 producing the maximum yield of 24 t ha-1. Seed yield varied from 1.1 t ha-1 (accession TVu 9604) to 4.9 t ha-1 (accession TVu 9510) among accessions with an average of 2.4 t ha-1. In guar, while the average dry matter yield of the 10 accessions was 9.5 t ha-1 , accession PI 323083 produced the highest yield (12.8 t ha-1). Seed yield varied between 2.5 t ha-1 (accession PI 263891) and 1.4 t ha-1 (accession PI 263877) with a mean of 2.2 t ha-1 over accessions. The results show that both cowpea and guar have great potential and because of their low water requirements, they could be excellent alternatives for the water-thirsty forage species such as alfalfa in the UAE. Both these crops are salt-tolerant and in addition, they are fast-growing high quality forages and have other economic uses, especially as vegetables. إمكانات للوبيا [Vigna unguiculata (L.) Walp.] والغوار [Cyamopsis tetragonoloba (L.) Taub.] لعربيةا المتحدة 14660)، ب.ص. ICBA زألمرا ليولدا عقراللز لملحيةا (محمد دهشا و * راو ناندوري أنباتات بقلية علفية بديلة في لةدو الإمارات لعربيةا لمتحدةا تم اختبار تهدف الأبحاث لتيإ تم اهتنفيذ لىإ تحديد محاصيل بديلة، خاصة من البقوليات، ذات احتياجات مائية قليلة للكوذ لهاالاستبد بالأنواع ملخص: ، بيد، الإمارات من الغوار لمدة 10 بالإضافة لىإ يا سلالة من للوبا 23 لتيإ تستهلك آميات آبيرة من لمياها لعذبةا في نظم إنتاج الأعلاف في لةدو الإمارات لعربيةا المتحدة. لذلك لسلالةا 18,1 لنبتة للوبياا، بلغ متوسط نتاجيةإ المادة لجافةا لتحديد مدى تهاءفاآ تهارقدو على لتأقلما مع لبيئةا لمحليةا. بالنسبة 2009 يوما ً خلال صيف 120 سلالات TVu 9604 طن بالهكتار لسلالةا(1,1 طن بالهكتـار. حتاوترو نتاجيةإ البذور بين 24 علىأ نتاجيةإ للعلف الجـاف بلغت TVu 9480 طن بالهكتـار حيث سجلت حتى (4,9 طن بالهكتار لسلالةا(TVu 9510 مع (بلغ متوسط ناتج 2,4 ...","author":[{"dropping-particle":"","family":"Rao","given":"N K","non-dropping-particle":"","parse-names":false,"suffix":""},{"dropping-particle":"","family":"Shahid","given":"Mohammed","non-dropping-particle":"","parse-names":false,"suffix":""}],"container-title":"Emir. J. Food Agric.","id":"ITEM-1","issue":"2","issued":{"date-parts":[["2011"]]},"page":"147-156","title":"Potential of cowpea [Vigna unguiculata (L.) Walp.] and guar [Cyamopsis tetragonoloba (L.) Taub.] as alternative forage legumes for the United Arab Emirates","type":"article-journal","volume":"23"},"uris":["http://www.mendeley.com/documents/?uuid=712ebc8c-2349-33ac-9e4a-6ccbf4d5d90e"]}],"mendeley":{"formattedCitation":"(7)","plainTextFormattedCitation":"(7)","previouslyFormattedCitation":"(7)"},"properties":{"noteIndex":0},"schema":"https://github.com/citation-style-language/schema/raw/master/csl-citation.json"}(7) which indicates the production gap of 33.3% in dry matter and

Therefore, this project is aimed to evaluate reaction to cowpea genotypes to dry matter and seed yield production

2. Material and methods

This study was conducted on-station at three research centers: AMARC (Arba Minch Agricultural Research Center), BARC (Bonga Agricultural Research Center), and HARC (Hawassa Agricultural Research Center) from March 2018 - to November 2020 during the main cropping season. The major agro-climatic and study area map is presented in Figure 1. The soil of experimental sites at 0-30 cm depth was tested for soil texture, pH, cation exchange capacity (CEC), organic carbon (OC), organic matter (OM), total nitrogen (TN), and available phosphorus (P) in Soil laboratory to determine selected physicochemical properties of the soil (Table 1).

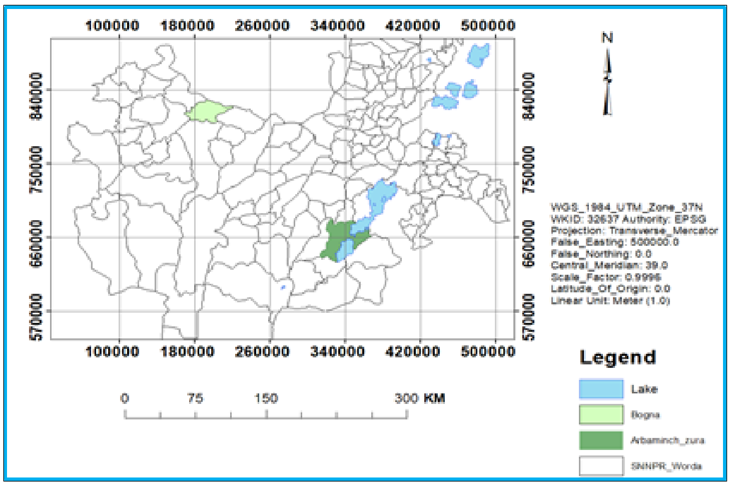

Figure 1 Map of production sites

Table 1 Coordinates, altitude, climatic data, soil physical and chemical characteristics of experimental sites

Characteristics	AMARC	BARC	HARC
Longitude	37° 35'10.5"E	36° 13'E	38° 18'30''E
Latitude	6°06'47"N	7°19'N	6°24'30''N
Altitude (meter above sea level)	1206	1200	1572
Rainfall (av. mm)	750-818	1050-1200	1300
Temperature maximum (^{0}C)	30	20	28.05
Temperature minimum (^{0}C)	20	15	13.10
pH (H2O 1:2.25)	6.7	6	6.85
CEC (me/100 g)	32.4	23	21
OC%	2.73	2.34	2.12
OM%	4.7	4.03	3.4
Total Nitrogen %	0.203	0.183	0.15
Available Phosphorus (PPM)	65.14	21.28	25.3
Texture	Clay loam	Clay loam	Sandy loam
References	(8)		(9)

Treatments on field experiment of cowpea were including five accessions: ILRI_9333, ILRI_9334, ILRI_11114, ILRI_12668, and ILRI_12713 with one released variety: Temesgen as standard-check in the main station of three centers: AMARC, BARC, and HARC of Southern Agricultural Research Institute (SARI). The experiment was conducted for three years from March 2018 to November 2020. All accessions were brought from International Livestock Research Institute except the Temesgen variety which was from the Ethiopian Institute of Agricultural Research (EIAR). It was laid out in a randomized complete block design with three replications. It was planted in five rows plot (3*3=9m^2) with a spacing of 60 (between rows)*30 (between plants) cm with plots of 100 cm and replication of 150 cm. Two seeds of each variety were planted in a hole at the plowed and harrowed plot to reduce to one after emergence. NPS blended fertilizer composed of 19% nitrogen: 37% P_2O_5:7% sulfur) 100 kg/ha was applied for all plots at planting. Hoe weeding of all plots was undertaken until the flowering starts and seed development to enable the plants to develop under non-limiting conditions.

Growth, yield, and yield component parameters: vine length (VL cm), branch number (NBPP), leaf to stem ratio (LSR), dry matter yield (DMY t/ha), seed yield (SY t/ha), and yield components; and crop phenology: days to 50% flowering and seed harvesting were computed for three consecutive years. The Vine length was measured for five lablab plants each randomly selected from central net rows of the plot using a tape meter from ground to top at forage harvesting. Branches of five randomly selected plants were counted and averaged per plant. LSR was computed using the formula leaf yield (LY t/ha) divided by stem yield (SY t/ha). 500 gram (250 g stem and 250 g leaves) sample of leaf and stem independently was collected from each plot and dried with oven at 65^{0}C for 24 hours to drive constant dry weight. Fresh matter yield was measured from each plot to calculate dry matter yield. Dry matter yield was computed using the formulas: $DM\% = \frac{ODW}{FW} x100$ ......*(1)* Where: DM% is dry matter percent; ODW is oven-dry weight, dried into the constant weight through 65^{0}C for 24 hrs. FW is the fresh weight of the sample from the field. $DMY\ (t/ha) = FMY(t/ha) * DM\%$ .... (2) Where: DMY is dry matter yield in ton per hectare, FMY is fresh matter yield in ton per hectare converted from a plot yield, and fresh matter yield was computed from the whole plots. Seed yield (SY t/ha) and yield components: pod length (PL cm), pod per plant (PPP), seed per pod (SPP), 100 seed weight (100SW g), and harvest index (HI) were measured and presented in this project. Seed yield was weighed per plot in spring balance after a moisture test of 12% using a graduated moisture tester expressed in ton per hectare.

Cowpea aphid (*Aphis craccivora*) infestation was calculated by using the area under the infestation progress curve (AUIPC). The formula used:

$$\text{AUIPC} = \sum_{i=1}^{n-1} \left[\frac{(X_i + X_{i+1})}{2}\right] \left[(t_{i+1} - t_i)\right]$$

Where: X_i = Degree of infestation at the ith observation X_{i+1} = Degree of infestation at the (i+1)th observation T_i = Time in days for the ith observation T_{i+1} = Time in days for the (i+1)th observation n= Total number of observations

Collected data were analyzed using the analysis of variance procedure and least significance difference ($LSD_{0.05}$) of Genstat statistical software Version 18, VSN International Ltd, UK (10).

3. Results and discussion

3.1. Vine length

The Vine length of cowpea genotypes in three years at three locations is presented in Table 2. Significant differences in vine length at the 95% probability level were observed in all the varieties of cowpea studied with ILRI_9334 and ILRI_12713 performing significantly ($p<0.001$) better compared to the other varieties. The mentioned genotypes ILRI_9334 and ILRI_12713 produced higher vine lengths of 123.6 and 105.83 cm at AMARC, 95.37and 94.73 cm at BARC, and 103.6 and 98.8 cm at HARC with overall mean values of 107.52 and 99.79 cm. Environmental variation also determines the height of the crop in the experiment. A higher mean vine length of 121.1 cm was obtained in 2020 at AMARC and 96.8 cm at BARC. Previous mean values reported for vine length of similar genotypes ILRI_9334 and ILRI_12713 were 105.6 and 122.36 cm (6) which is closely similar to the present result. Plant height contributes to and plays a great role in above-ground biomass accumulation of forage crop production (11). This may be due to the taller a plant, the higher the amount of light energy absorbed and the higher the rate of photosynthesis, and consequently the amount of assimilation produced by the leaves (12).

Table 1 Vine length of different cowpea genotypes across locations over a year

Genotype	AMARC				BARC				HARC	Overall Mean
	2018	2019	2020	Mean	2018	2019	2020	Mean	2018	
ILRI-11114	83.4	76.5	115.4	91.77	55.6	75.4	100.3	77.10	82.2	83.69
ILRI-12688	69.9	50.4	129.2	83.17	94.9	97	95.3	95.73	72.4	83.77
ILRI-12713	89	80.1	148.4	105.83	98.3	89.6	96.3	94.73	98.8	99.79
ILRI-9333	76.5	74.3	118.2	89.67	75.9	65.9	90	77.27	82.7	83.21
ILRI-9334	111.6	139.1	120.1	123.60	77.3	115.8	93	95.37	103.6	107.52
Temesgen	96.1	-	95.5	63.87	39.7	87.4	106	77.70	98.5	80.02
Mean	87.8	70.1	121.1	93.00	73.6	88.5	96.8	86.30	89.7	89.67

CV% 24.5 $LSD_{0.05}$: G=21.84 Y=15.44 GxY=37.83

3.2. Branch number per plant

Branch number per plant of cowpea genotypes at forage harvest showed significant ($P<0.001$) variation across locations over the year (Table 3). Cowpea genotype branching performance was considered an important parameter during the selection of crops for better forage yield and ground cover to reduce soil erosion and moisture retention (6). The mean number of branches at forage harvest was ranging from 5.3 to 7.78. ILRI_9334 genotype produced a higher number of branches while the lowest branch production was detected for Temesgen (standard check). Good production of branches in cowpea may contribute to high biomass yield and is important in haymaking for milking cows. The branching performance of cowpea genotypes in this experiment was also influenced by environmental and genetic factors (13) and it is required to select genotypes with higher branches to fulfill green forage supplement.

Table 2 Branching performance of cowpea genotypes across locations over the year

Genotypes	AMARC				BARC				HARC	Overall mean
	2018	2019	2020	Mean	2018	2019	2020	Mean	2018	
ILRI-11114	5.6	6.27	7	6.29	8.2	6.87	10.6	8.6	4.67	6.52
ILRI-12688	5.87	5.13	3.93	4.98	10.6	6.67	9.73	9	4.67	6.22
ILRI-12713	4.27	5.4	5.67	5.11	8.07	7.13	10.6	8.6	6	6.57
ILRI-9333	6.8	5.72	5.2	5.91	7.27	5.73	10.2	7.73	5.33	6.32
ILRI-9334	5.47	7.73	7.87	7.02	9.27	9.8	10.93	10	6.33	7.78
Temesgen	4.93	-	5.8	3.58	7.6	7	9.33	7.98	4.33	5.30
Mean	5.49	5.04	5.91	5.48	8.5	7.2	10.23	8.64	5.22	6.45

CV% 16.9 $LSD_{0.05}$: G=1.4 Y=0.9 GxY=NS

3.3. Leaf to stem ratio (LSR)

The mean values of leaf to stem ratio of cowpea genotypes are presented in Figure 2. No significant (P>0.05) variation of leaf to stem ratio was recorded among cowpea genotypes in the present experiment. However, ILRI-9333 and ILRI-11114 had higher values of leaf to stem ratio, numerically with an overall mean value ranging from 0.52-1.497. The value of cowpea leaf to stem ratio 0.52-1.497 determines the criteria for evaluating the quality of the pasture grass. The higher proportion of leaves compared to stem indicate a better nutritive value of forages (14).

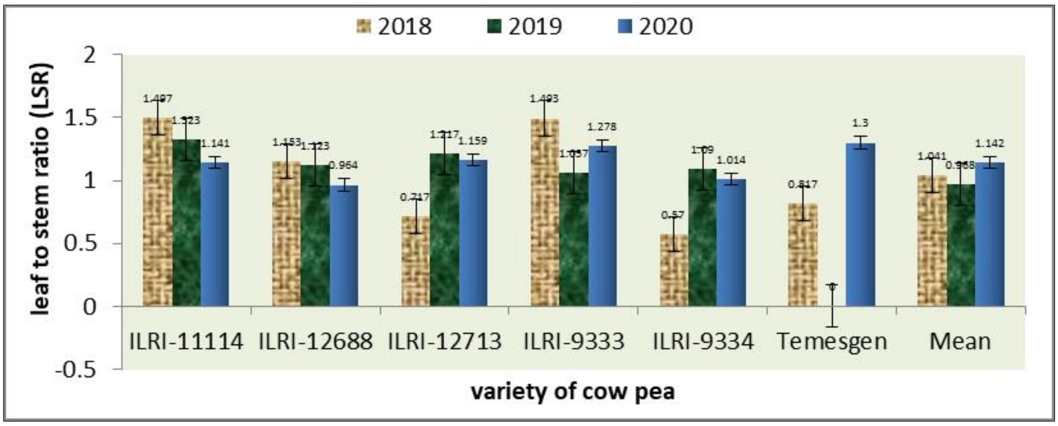

Figure 1 Mean values of leaf to stem ratio of the six cowpea genotypes at 2018-2020

3.4. Dry matter yield

Mean aerial dry matter accumulation of cowpea genotypes across locations over the year is presented in Table 4. There was a significant (P<0.001) variation in dry matter accumulation among cowpea genotypes across experimental sites over the growing period. Dry matter yield was ranging from 2.89 t/ha at BARC in 2019 for variety Temesgen to 13.25 t/ha at AMARC in 2020 for genotype ILRI_12713. This may be related to genotypes responding to different environments in a different manner of branching and plant height that could be resulted in higher dry matter in different locations. Overall mean values indicated ILRI_12713 (8.87 t/ha) followed by ILRI_9334 (8.44 t/ha) and ILRI_11114 (8.4 t/ha) produced more dry matter yield than others and the Temegen variety. Dry matter yield advantage of the genotypes ILRI_12713 was 15.04% ILRI_9334 was 9.5% and ILRI_11114 was 8.95% over the recently released variety (Temesgen). It was reported previously that there was a significant (P<0.05) variation of dry matter yield among commercial and improved cowpea varietal groups (15). The present higher dry matter yield of 13.25 t/ha for ILRI_12713 was lower than the previous report (16.1 t/ha) in other locations for similar genotypes (6). However, it was higher than the mean values of 6.7 t/ha for five cowpea accessions (16) and 8.76 t/ha for three improved cowpea varieties (15). Cowpea crop dry matter production variation for different genotypes in the present study agrees with recent studies on cowpea varieties (17).

Table 3 Interaction Effect of Location*Year*Variety on Dry Matter Yield (DMY t/ha) of Cowpea in Southern Ethiopia 2018-2020

Location	Year	ILRI_11114	ILRI_12688	ILRI_12713	ILRI_9333	ILRI_9334	Temesgen	Loc*Year Mean
AMARC	2018	9.69^{c-h}	8.35^{e-i}	10.91^{a-e}	12.42^{ab}	5.16^{k-n}	10.36^{b-g}	9.48
	2019	10.92^{a-e}	7.39^{h-k}	8.99^{d-i}	8.95^{d-i}	7.97^{f-j}	-	8.84
	2020	12.86^{ab}	10.92^{a-e}	13.25^{a}	9.65^{c-h}	11.96^{a-c}	12.60^{ab}	11.87
BARC	2018	7.96^{g-j}	11.29^{a-d}	10.60^{b-f}	10.93^{a-e}	11.88^{a-c}	8.51^{e-i}	10.19
	2019	3.68^{mn}	5.62^{j-m}	4.04^{l-n}	3.99^{l-n}	6.54^{i-l}	2.89^{n}	4.46
	2020	5.29^{k-n}	4.37^{l-n}	5.41^{j-n}	4.69^{l-n}	4.01^{l-n}	4.20^{l-n}	4.66
HARC	2018	5.1^{k-n}	4.5^{l-n}	4.4^{l-n}	4.5^{l-n}	4.2^{l-n}	4.21^{l-n}	4.45
Genotype Mean		8.4	7.99	8.87	8.44	7.92	7.71	8.25

CV%=20.1, $LSD_{0.05}$=2.62, P-value<0.001

3.5. Seed yield and yield components

Mean values of seed yield (SY t/ha) and yield components: pod length (PL cm), seed per pod (SPP), hundred seed weight (100SW g), and harvest index (HI) were presented in Table 5. SPP and HI were not significantly varied among genotypes in the present experiment while PL and 100SW were varied at *P=0.0009* and *P<0.0001* level of significance, respectively. Pod length was ranging from 11.8 cm for Temesgen variety (standard check) to 18.53 cm for ILRI_12713. Higher pod length for genotype ILRI_12713 was at par with ILRI_12688 and ILRI_11114. Hundred seeds' weight was ranging from 8.67 g for ILRI_9334 to 14.67 g for ILRI_12713 and ILRI_12688. Seed yield of cowpea genotypes was significantly (*P=0.0178*) varying from 1.3 t/ha for Temesgen (standard check) to 3.7 t/ha for ILRI_11114 and at par with ILRI_12713 and ILRI_12688. Genotypic variation in grain yield and yield components (18) was reported previously for common beans. The mean seed yield of 2.8 t/ha for the present experiment was higher than 2.2 t/ha for seven cowpea varieties in the North West lowlands of Ethiopia (4). It was better than the 2.4 t/ha seed yield in the United Arab Emirates for 23 ADDIN CSL_CITATION {"citationItems":[{"id":"ITEM-1","itemData":{"abstract":"Investigations were conducted with an objective to identify alternative crops, especially legumes with low water requirement to replace the water intensive conventional species in forage production systems in the United Arab Emirates (UAE). Thus, the performance of 23 accession of cowpea (Vigna unguiculata) and 10 accessions of guar (Cyamopsis tetragonoloba) was evaluated over a growing period of 120 days during summer in 2009. In cowpea, the dry matter yield, averaged over the accessions was 18.1 t ha-1 with accession TVu 9480 producing the maximum yield of 24 t ha-1. Seed yield varied from 1.1 t ha-1 (accession TVu 9604) to 4.9 t ha-1 (accession TVu 9510) among accessions with an average of 2.4 t ha-1. In guar, while the average dry matter yield of the 10 accessions was 9.5 t ha-1 , accession PI 323083 produced the highest yield (12.8 t ha-1). Seed yield varied between 2.5 t ha-1 (accession PI 263891) and 1.4 t ha-1 (accession PI 263877) with a mean of 2.2 t ha-1 over accessions. The results show that both cowpea and guar have great potential and because of their low water requirements, they could be excellent alternatives for the water-thirsty forage species such as alfalfa in the UAE. Both these crops are salt-tolerant and in addition, they are fast-growing high quality forages and have other economic uses, especially as vegetables. إمكانات للوبيا [Vigna unguiculata (L.) Walp.] والغوار [Cyamopsis tetragonoloba (L.) Taub.] لعربيةا المتحدة 14660)، ب.ص. ICBA زآلمرا ليولدا عقراللز لملحيةا (محمد دهشا و * راو نناندوري أنباتات بقلية علفية بديلة في لةدو الإمارات لعربيةا المتحدة تم اختبار تهدف الأبحاث لتيا تم اهتنفيذ لىإ تحديد محاصيل بديلة، خاصة من البقوليات، ذات احتياجات مائية قليلة لكوذ لهاالاستبد بالأنواع ملخص: ، بيد، الإمارات من الغوار لمدة 10 بالإضافة لىإ يا سلالة من للوبا 23 لتيا تستهلك آميات آبيرة من لمياها لعذبةا في نظم إنتاج الأعلاف في لةدو الإمارات لعربيةا المتحدة. لذلك لسلالةا 18,1 لنبتة للوبيا، بلغ متوسط نتاجيةإ المادة لجافةا لتحديد مدى تهاءفاآ تهارقدو على لتأقلما مع لبيئةا لمحليةا. بالنسبة 2009 يوما ً خلال صيف 120 سلالات TVu 9604 طن بالهكتار لسلالةا(1,1 طن بالهكتـار. حتاوترو نتاجيةإ البذور بين 24 علىأ نتاجيةإ للعلف الجـاف بلغت TVu 9480 طن بالهكتـار حيث سجلت حتى (4,9 طن بالهكتار لسلالةا(TVu 9510 مع (بلغ متوسط ناتج 2,4 ...","author":[{"dropping-particle":"","family":"Rao","given":"N K","non-dropping-particle":"","parse-names":false,"suffix":""},{"dropping-particle":"","family":"Shahid","given":"Mohammed","non-dropping-particle":"","parse-names":false,"suffix":""}],"container-title":"Emir. J. Food Agric.","id":"ITEM-1","issue":"2","issued":{"date-parts":[["2011"]]},"page":"147-156","title":"Potential of cowpea [Vigna unguiculata (L.) Walp.] and guar [Cyamopsis tetragonoloba (L.) Taub.] as alternative forage legumes for the United Arab Emirates","type":"article-journal","volume":"23"},"uris":["http://www.mendeley.com/documents/?uuid=712ebc8c-2349-33ac-9e4a-6ccbf4d5d90e"]}],"mendeley":{"formattedCitation":"(7)","plainTextFormattedCitation":"(7)","previouslyFormattedCitation":"(7)"},"properties":{"noteIndex":0},"schema":"https://github.com/citation-style-

Table 4 Mean values of seed yield and yield components of cowpea genotypes

Genotypes	SPP	PL cm	HI	100SW	SY t/ha
ILRI-11114	14.87	17.8ab	0.289	11	3.7a
ILRI-12688	13.93	17.87ab	0.307	14.67	3.33ab
ILRI-12713	15.46	18.53a	0.257	14.67	3.37ab
ILRI-9333	14.53	16.8ab	0.259	12.33	2.49bc
ILRI-9334	15.13	13.87b	0.223	8.67	2.63bc
Temesgen	10.21	11.58c	0.165	11.67	1.3c
Mean	14.02	16.08	0.25	12.17	2.80
P value	0.5986	<0.0009	0.0996	<0.0001	0.0178
$LSD_{0.05}$	NS	1.6986	NS	4.3	0.9314
CV%	7.4	5.59	22.75	5.1	17.8

SPP: seed per pod, PL: pod length, HI: harvest index, 100SW: hundred seed weight, SY: seed yield

3.6. Aphid infestation in terms of Aphid count, AUIDC, and Pest severity index (PSI)

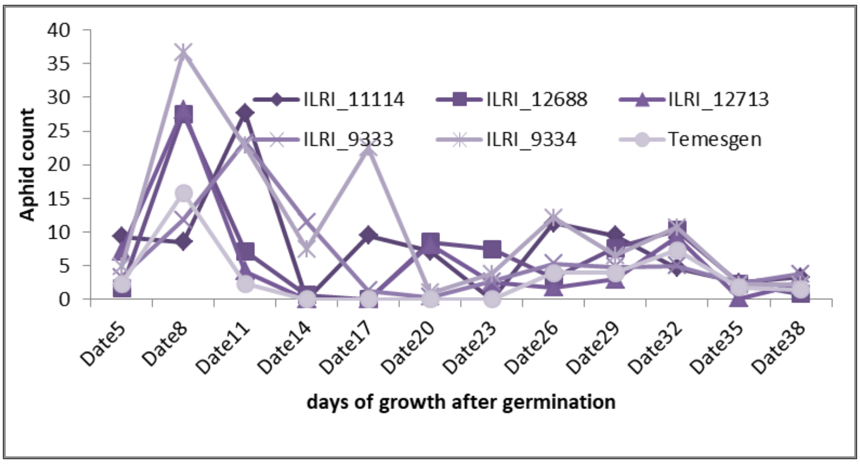

Figure 2 Aphid count in the days of cowpea growth illustrated for six genotypes 2018-2020

Cowpea aphids are usually distressing the production of pulses and legume crops. The aphid counts per plant are presented in Figure 3. Infestation of cowpea aphids in the present experiment was higher at earlier weeks than in the latest and maturing stage. ILRI-9334 genotypes infested at 36.67% on the eighth day of data collection while the lowest (2.17%) was at the date was 38. Most genotypes are affected at higher rates by aphids starting from date 17 to forward. Regression analysis of dry matter and seed yield affected by aphid infestation in terms of AUIPC and PSI is presented in Figure 4. Linear regression of dry matter yield with AUIPC indicates there was a significant (P=0.03) negative association between them and PSI showing aphid infestation has no significant (P>0.05) effect on dry matter yield production of cowpea. AUIPC and PSI have been negatively associated with seed production of cowpea that one unit aphid increment reduces 0.0227 units and 0.0113 units of seed yield. This surely indicates that infestation of aphids in the cowpea field influences dry matter yield and seed yield. Aphid infestation sucking the leaf system may hinder the function of stomata which consequently interferes with the crop morphology. Other reports also indicated that aphids can cause direct feeding damage to plants when in large numbers as they remove sap, which can cause wilting of plants death and secretion of honeydew by aphids can cause secondary fungal growth, which inhibits photosynthesis and can decrease plant growth (19). There was also another report confirming genotypes' susceptibility to aphids while others give optimum yield resisting the infestation (20).

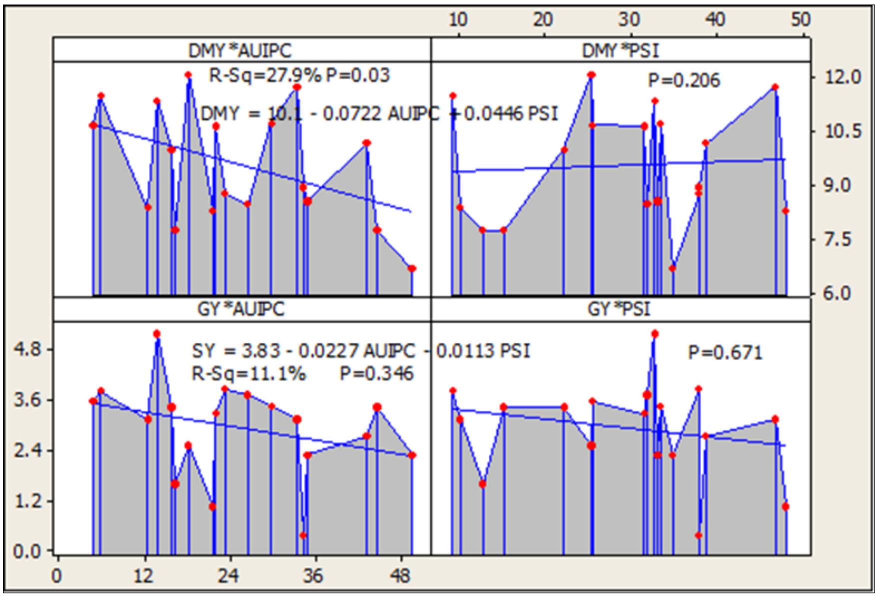

Figure 3 Regression analysis of dry matter and seed yield with the area under aphid infestation progress curve (AUIPC) and Pest severity index (PSI) of cowpea aphid 2018-2020

3.7. Pearson correlation of parameters

Correlation of vine length (VL), branch number (BN), dry matter yield (DMY), seep per pod (SPP), harvest index (HI), seed yield (SY), and aphid incidence at the last day of scoring (Ahid@LD) were assessed as presented in Table 6. Aphid incidence was negatively correlated with all growth and yield parameters. Dry matter yield was positively correlated with branch number and vine length but not statistically (P=0.736 and 0.69) significant. Seed yield was positively and significantly (P= 0.047 and 0.015) correlated with seed per pod and harvest index. This indicates the biomass yield was a function of the high contribution of the growth parameters and seed yield was the product function of yield components such as seed per pod and harvest index. This was presented for oats seed production during 2016-to 2017 (21).

Table 5 Pearson correlation of growth and yield parameters and aphid incidence

	VL	BN	DMY	SY	Aphid@LD	SPP
BN	0.848*					
DMY	0.21	0.178				
SY	0.22	0.446	0.625			
Aphid@LD	-0.359	-0.735	-0.240	-0.322		
SPP	0.583	0.781	0.686	0.818*	-0.694	
HI	-0.077	0.253	0.481	0.9**	-0.336	0.684

BN: branch number, DMY: dry matter yield, SY: seed yield, Aphid@LD: aphid at leaf development, SPP: seed per pods, HI: harvest index, VL: vine length

4. Conclusion

The study on the evaluation of cowpea genotypes for dry matter and seed yield under aphid stress could provide appreciable results which significantly contribute to the feed supply of the crop-livestock farming system of Ethiopia. Legume forages like cowpea improves the feed quantity and quality. Seed production has also been the objective of this project. In three years of the experiment across three locations in southern Ethiopia higher seed yields of 3.7, 3.37, and 3.33 t/ha from ILRI_11114, ILRI_12713, and ILRI_12688, respectively while the standard check was 1.3 t/ha. A higher dry matter yield of 13.25 t/ha was obtained from ILRI_12713 in AMARC during the 2020 cropping season while the minimum yield of 2.89 t/ha was from Temesgen (standard check). Thus, it was concluded from the experimental findings that the genotypes in this experiment could be highly comparable with the standard check and used as an alternative material. Inclusion of highly performed genotypes in the breeding program of forage legumes warranted for forage production in the crop-livestock farming system of Ethiopia.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors claimed no conflict of interest in this work.

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