EVALUATION OF POTTING MIXTURES AND PROVENANCE ON EMERGENCE AND SEEDLING GROWTH OF GUM ARABIC (*Senegalia senegal* [L.] Britton)

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ABSTRACT
The experiment was conducted at the Rubber Research Institute of Nigeria, Gum Arabic nursery Sub-station Gashua, Yobe (120 46' N longitude 110 00'E and altitude 360m above sea level) to evaluate the effect of potting mixtures and provenance on the emergence and seedling growth performance of gum arabic (*Senegalia senegal*) in 2017 and 2018. The treatments consisted of eight (8) difference potting mixtures of top soil, river sand cowdung in the ratios (2:0:1, 2:0:3, 2:1:1, 2:1:3, 2:2:1, 2:2:3, 2:3:1, 2:3:3) and two (2) provenance (Yusufari and Gujba). The experiments were laid out in Randomized Complete Design in three (3) replications. Potting mixture showed no significant difference in days to emergence of *S. senegal* while seeds of Yusufari origin significantly influenced early days to emergence in both years of the study. At three (3) months after sowing (3 MAS) with ratios 2:1:1, 2:3:1 and 2:2:3 though statistically similar, significantly gave superior seedlings height in 2017 and 2018 experimentation with Gujba provenance producing taller seedlings. At 3MAS with ratio 2:1:1, 2:0:1, 2:1:3 and 2:2:1 thought statistically comparable, significantly increased seedling stem diameter, number of primary branches and canopy spread than other ratios in both seasons. Also, at 3MAS potting mixtures of 2:1:1, 2:1:3, 2:3:1 and 2:2:3, thought statistically similar, significantly increased height at first branch and root length more than the other ratios regardless of the study year. The study concluded that Gujba provenance gave superior seedling growth performance in most of the sampling period. The study concluded that potting mixture in the ration 2:1:1 was most appropriate for morphological growth characters of gum Arabic provenances. It is therefore recommended for profitable seedling production in the study area.

Keywords: Emergence, Gum Arabic, Potting mixture, Provenance, Seedling.

INTRODUCTION
Gum arabic "desert gold of Africa" is the dried exudates obtained from stems and branches of *S. Senegal* or closely related species of *Senegalia* that belong to the family fabaceae (Wekesa *et al.*, 2009; and Dorthe, 2000). *Senegalia Senegal (S. Senegal)* is the most important tree in Sudan and Sahelian agro-ecological zones of Nigeria because of its product gum arabic. The gum is a food addictive highly valued at the international markets. Sudan is the greatest producer and exporter of gum with an average export of 29,678 tons/annum from 2001 to 2010 representing 48% of total world export followed by Nigeria with a record of 20,000 tons/annum representing 28%. Chad maintained a third position with a supply of 12,428 tons/annum representing 20% of world output within the same period. The balance of 5% was produced by the remaining African producing countries. The volume of international trade on gum arabic stands at 63,083 tons/annum averaged over 10 years (International Trade Centre [ITC], 2010). The declining gum exports from Sudan (47%) have increase demand for gum arabic in other producing countries like Nigeria and Chad.

The gum is obtained from the trees following tapping or natural exudation during the dry season. The gum provides an important source of income for rural people. Like other trees

crops, the tree under goes immaturity of 4-7 years depending on species and management. As soon as the trees start producing, gum yield increase progressively and stabilizes from 15-25 years before declining. The economic life span of the tree is 25-30 years. However, trees of about 40 years still produce gum. The tree is a deciduous shrub usually branched from the ground and is very thorny. Powerful hocked thorns 3-5mm long with enlarged bases appear at the nodes of the branches, usually in threes. They are sharp, with the middle one hooked downward and the lateral ones curved upward (Orwa *et al.,* 2009).

In Nigeria high concentration of *S. senegal* which produces grade 1 gum arabic is found in North Eastern part of the country (Ojiekpon and Aghughu, 1997). Just like every other center of origin that constitutes centre of biodiversity, in Nigeria *S. senegal* occurs naturally in association with other gum producing species like *Acacia sieberiana*, *Acacia polyacantha*, and C*ombretum nigriçans*.

Grade one gum arabic is a multifunctional food additive used in confectionaries, pharmaceuticals, food and beverages, brewing among others (Leung, 1980; and Anderson, 1993). The plant is useful for afforestation in the arid and semi-arid regions with desertification problems, soil reclamation and windbreaks. The leaf litters form an excellent source of nitrogen and organic matter which help to improve soil structure and fertility, and when in association with microbial symbionts restores soil N through nitrogen fixation (Cossalter, 199; and Ojiekpon *et al*. 2007). The success of any plantation establishment depends largely on the use of good seedlings raised in the nursery. Presently, potting mixtures used in raising *S. senegal* seedlings in Nigeria are those recommended for dry-land tree seedlings used in desertification and erosion programmes. During pot filling, topsoil, river sand and cowdung are mixed in the ratio of 2:2:1 by volume (Pinyopusaverk *et al*., 1991; and Doran, 1997). As a tree legume the seedlings may not require high level of nutrition since it has been established to fixed appreciable amount of nitrogen (Ojiekpon *et al*., 2007). Owing to the attractive price and demand for gum at both local and international markets as well as the need for scientific information on the agronomic practices of the crop, this study was carried out with the following objectives: To determine appropriate top soil, river sand and cowdung ratio suitable for emergence and growth characters of *S. senegal* seedlings.

MATERIALS AND METHODS
The experiment was conducted at the Rubber research institute of Nigeria, Gum Arabic Sub-Station, Gashua, Yobe State (12^0 450' N, 11^0 00' E and altitude 360m above sea level), Sahel Savanna ecological zone of Nigeria in 2017 and 2018. The potting mixture used were top soil, River Sand and Cowdung in the following ration (2:0:1, 2:0:3, 2:1:1, 2:1:3, 2:2:1, 2:2:3, 2:3:1, 2:3:3) and two (2) provenance laid out in Randomized Complete Design in three (3) replications. The two (2) Gum Arabic seed provenance were obtained from Gujba and Yusufari Local Government Areas of Yobe State. The top soil was collected from arable farm at the experimental site, river sand from sand vendor while the organic manure (Cow dung) was sourced from cattle Fulani settlement around the Sub-station. Polythene bags measuring 7.5×20cm were used for the study. Prior to seed sowing, the polythene bags were watered morning and evening for two days. Two (2) seeds were sown in a polythene bag and were later thinned to one seedling per polythene bag. The study was carried out under shade in the nursery station because gum Arabic belt are usually very hot and dry with temperatures sometimes as high as 43^0c. The shade protected the tender seedlings against Sun scotch. Seedlings were watered morning and evening for three months except on days with rain fall. Weeding was carried out forth nightly to ensure weed free gum Arabic seedlings. Weeds that emerged within the polythene bag were hand-picked and discarded and those at the avenues were hoe weeded

and raked away. The parameters observed were days to emergence, seedling height, stem diameter, canopy spread and the data collected were subjected to analysis of variance. Fisher's test was used to test for significant differences among treatment means as described by Snedecor and Cochran (1967). Treatment means were compared using Duncan's multiple Range Test (DMRT) (Duncan, 1955). The data was analyzed using the general linear model procedure of statistical analysis system software version (SAS Institute, 2000).

RESULTS AND DISCUSSION
Days to Emergence
It was observed that statistical differences existed in days to emergence of gum arabic provenances of Gujba and Yusufari. Seeds obtained from Yusufari had early days to emergence in both years (3.80 and 3.89) compared with those collected from Gujba. As presented in Table 1, the potting mixtures had no significance differences statistically on early emergence but it has been observed early emergence in the potting mixture of 2:3:3in both years, followed by 2:2:1 in 2017 and 2:2:3 in 2018.The early emergence of Yusufari provenance (smaller seeds) is in line with the finding of Marshall (1986) who reported highest percentage of small seed emergence of *Sesbania species*.

Table 1: Days to Emergence as affected by Potting Mixtures in the Nursery at Gashua gum Arabic Provenance

Treatments	2017	2018
Potting mixtures		
2:0:1	5.44	5.48
2:0:3	5.45	5.40
2:1:1	5.50	5.46
2:1:3	5.31	5.33
2:2:1	5.05	5.32
2:2:3	5.09	5.16
2:3:1	5.29	.31
2:3:3	4.82	5.20
SE ±	0.30	0.30
LS	NS	NS
Provenance		
Gujba	6.69[b]	6.77[b]
Yusufari	3.80[a]	3.89[a]
SE±	0.10	0.10
LS	**	**
M x P	NS	NS

Means followed by the same letters within a column are not significantly different. ** = Significant at 1% levels significantly, SE± = Standard Error. NS = not significant and M x P = interaction between mixture and provenance.

As presented in Table 1, the increase in days to emergence of seed from Gujba (larger seeds) is at variance with the general assertion that larger seed emerge early and at a higher rate than smaller seeds. Also, larger seeded seedlings performance better than small seeded seedlings (Rabecca *et al.* 2007).

Seedling Height (cm)
The result in Table 2 shows statistically significances difference in Seedlings height (cm) between the potting mixtures is both months after sowing except in July were it shows no significant differences statistical. At the month of June the potting mixtures 2:3:1, 2:1:1 and

2:0:1 produces taller seedlings in 2017 and ratios 2:1:1 and 2:3:1 in 2018 which statistically are similar. However, at the month of august, ratio 2:1:1 significantly gave superior seedling height than other potting media. Potting mixture 2:0:3 recorded the shortest seedlings compared to rest of the potting mixtures. It's also observed there was no significant differences statistically among the provenance except in august were Gujba gave highest seedling height of gum Arabic in both years. The superior seedling height observed with seeds from Gujba origin may be due to the large seed size which may imply large deposit of carbohydrate and protein content that must have given the germinated seed advantage over smaller seeds obtained from Yusufari. Good emergence and shoot length due to high quality seeds have been reported in *Acacia nalotica* (Shivanna *et al.* 2002).

Table 2: Seedlings Height (cm) as affected by Potting Mixture at Gashua Gum Arabic Provenances

Year/month	2017			2018		
	June	**July**	**August**	**June**	**July**	**August**
Treatment	**1**	**2**	**3**	**1**	**2**	**3**
Potting Mixtures						
2:0:1	8.27[a]	15.88	28.13[bc]	8.23[abc]	15.78	29.13[bc]
2:0:3	7.26[c]	15.53	21.42[c]	7.09[c]	l5.33	20.83[c]
2:1:1	9.68a	18.58	40.96[a]	9.62[a]	17.12	41.46[a]
2:1:3	8.07[abc]	17.50	33.17[ab]	8.00[bc]	16.92	32.71[abc]
2:2:1	8.86[ab]	18.83	30.38[abc]	8.78[ab]	18.58	30.17[abc]
2:2:3	8.63[a]	19.67	36.46[ab]	8.64[abc]	19.48	36.67[ab]
2:3:1	9.78[a]	18.90	30.25[abc]	9.75[a]	18.44	30.13[abc]
2:3:3	8.30[abc]	16.90	26.04[bc]	8.21[abc]	16.57	25.92[bc]
SE ±	0.50	1.80	3.60	0.50	1.90	3.80
LS	*	NS	*	*	NS	*
Provenance						
Gujba	8.82	17.55	33.88a	8.76	16.86	33.80a
Yusufari	8.39	17.89	27.82b	8.32	17.69	27.95b
SE ±	0.20	0.90	1.80	0.20	1.00	1.90
LS	NS	NS	*	NS	NS	*
M x P	NS	NS	NS	NS	NS	NS

Means followed by the same letters within a column are not significantly different. ** = Significant at 5% levels significantly, SE± = Standard Error. NS = not significant and M x P = interaction between mixture and provenance.

Stem Diameter

Table 3 results indicated that stem diameter of gum Arabic were not significantly ($P<0.05$) different in both months of the experimentation, except in the months of June 2017 and August 2018 were the potting mixture 2:0:3 and 2:1:1observed to give highest thicker stem diameter. However, no significant difference was observed statistically between the provenance and the interaction between mixtures and provenance. The superior stem diameter expressed by Gujba provenance is typical of seeds obtained from that origin. The result collaborate the findings of (Fakuta *et al.,* 2015).

Table 3: Stem Diameter of Gum Arabic Provenance as affected by Potting Mixture in the Nursery at Gashua

Year/month	2017			2018		
	June	July	August	June	July	August
Treatments	1	2	3	1	2	3
Potting Mixtures						
2:0:1	0.27^b	0.39	0.54	0.27	0.39	0.53a^b
2:0:3	0.71^a	0.37	0.44	0.26	0.37	0.44^b
2:1:1	0.30^b	0.38	0.61	0.29	0.38	0.61^a
2:1:3	0.28^b	0.36	0.53	0.28	0.36	0.52^{ab}
2:2:1	0.37a^b	0.40	0.53	0.29	0.37	0.53^{ab}
2:2:3	0.29^b	0.37	0.54	0.29	0.37	0.54^{ab}
2:3:1	0.31^b	0.41	0.59	0.31	0.41	0.58^{ab}
2:3:3	0.30^b	0.37	2.22	0.30	0.37	0.48^{ab}
SE ±	0.10	0.00	0.60	0.01	0.01	0.02
LS	*	NS	NS	NS	NS	*
Provenance						
Gujba	0.42	0.39	0.93	0.28	0.39	0.56
Yusufari	0.29	0.38	0.57	0.29	0.37	0.50
SE ±	0.10	0.01	0.30	0.01	0.01	0.01
LS	NS	NS	NS	NS	NS	NS
M x P	NS	NS	NS	NS	NS	NS

Means followed by the same letters within a column are not significantly different. * = Significant at 5% levels significantly. SE± = Standard Error. NS = not significant and M x P = interaction between mixture and provenance.

Canopy Spread of Gum Arabic Seedlings

Canopy spread of gum Arabic seedlings (Table 4) were significantly influenced by potting mixtures at both months after sowing. Potting mixture 2:1:1 (4.44), 2:2:3(12.64), 2:2:3(23.23) and 2:1:1(24.46), 2:3:1(11.55), 2:2:3(23.27) significantly produced wider canopy spread more than the rest of the potting media in 2017 and 2018, respectively. At 3 months after sowing, ratio 2:1:1 thought similar statistically with other ratios significantly gave the most outstanding canopy spread in both years of experimentation. Gujba provenance gave superior canopy spread compared to Yusufari seeds. The outstanding performance of canopy spread put up by Gujba provenance is reminiscent of the seed source. The specie has been reported to put robust seedling growth performance under the sahelian agro-ecological zone (Fakuta *et al.*, 2015).

Table 4: Canopy Spread of Gum Arabic Provenance as affected by Potting Mixture in the Nursery

Year/month	2017			2018		
	June	July	August	June	July	August
Treatments	1	2	3	1	2	3
Potting Mixtures						
2:0:1	4.27[ab]	8.44[b]	18.98[ab]	3.44[b]	8.54[ab]	17.94[ab]
2:0:3	3.75[b]	7.92[b]	11.92[b]	3.65[b]	7.57[b]	12.16[b]
2:1:1	4.44[a]	8.65[ab]	28.29[a]	4.46[a]	8.94[ab]	37.17[a]
2:1:3	3.71[b]	10.73[ab]	23.54[a]	3.90[ab]	10.62[ab]	23.17[a]
2:2:1	4.11[ab]	10.73[ab]	21.90[ab]	4.00[ab]	9.46[ab]	21.94[ab]
2:2:3	4.11[ab]	12.64[a]	23.23[a]	4.12[ab]	9.94[ab]	23.37[a]
2:3:1	4.29[ab]	9.65[ab]	21.30[ab]	4.09[ab]	11.55[a]	20.44[ab]
2:3:3	4.25[ab]	8.80[ab]	19.27[ab]	4.14[ab]	8.54[ab]	18.60[ab]
SE ±	0.20	1.30	3.00	0.20	1.11	3.10
LS	*	*	*	*	*	*
Provenance						
Gujba	4.45[a]	10.21	25.37[a]	4.37[a]	9.79	25.16[a]
Yusufari	3.79[b]	9.18	16.73[b]	3.60[b]	9.00	16.17[b]
LS	**	NS	**	**	NS	**
M x P	NS	NS	NS	NS	NS	NS

Means followed by the same letters within a column are not significantly different. * And** = Significant at 5% and 1% levels significantly. SE± =Standard Error. NS = not significant and M x P = interaction between mixture and provenance.

Number of Primary Branch

As presented in Table 5, at 1 month after sowing, there was no significant difference among the treatments with regards to number of primary branches in 2017. As the seedling grew, there was increase in number of primary branches of gum Arabic with Ratio 2:1:1 gave more number of primary branches with Yusufari seeds having the highest number of branches. The increased in number of primary branches by Yusufari seeds may be genetically influenced since the two provenances were subjected to the same treatment. This result is in line with the finding of (Fakuta and Ojiekpon, 2009).

Root Length (cm)

At 3 months after sowing, root length of gum arabic was significantly influenced by potting mixture in 2017 and 2018 during the study periods (Table 6). Ratio 2:1:1, 2:2:1 and 2:3:1 though statistically comparable with other ratios significantly produced longer root than other ratios. It was observed that the root length of gum Arabic were twice the height of the seedlings. This may be due to the inherent adaptation mechanism associated with of dry land species. This result is in line with the findings of Villar (2010) that seedlings in dry land areas tend to be height when plants are able to produce longer and vigorous root system which tends to increase the water requirements of the smaller shoots and it is considered a desirable trait in arid areas.

It was observed during the study that potting mixture affected root and shoots differently. This result collaborate the findings of Abebe (2000) who reported that different potting mixture influenced growth of shoot and root of Eucalyptus Amaldulensis in different way.

Table 5: Number of Primary Branches of Gum Arabic Provenance as affected by Potting Mixture in the Nursery

Year/month	2017			2018		
	June	July	August	June	July	August
Treatments	1	2	3	1	2	3
Potting Mixtures						
2:0:1	0.04	1.75^b	6.46^{ab}	0.08^{ab}	1.83^b	6.46^{ab}
2:0:3	0.04	1.29^b	5.25^b	0.04^b	1.25^b	4.92^b
2:1:1	0.25	2.08^b	8.54^a	0.46^{ab}	2.08^{ab}	8.50a
2:1:3	0.25	2.46^{ab}	6.58^{ab}	0.08^{ab}	2.42^{ab}	6.50^{ab}
2:2:1	0.21	2.25^{ab}	7.04^{ab}	0.14^{ab}	2.25^{ab}	7.00^{ab}
2:2:3	0.29	2.83^{ab}	6.92^{ab}	0.50^a	2.75^{ab}	7.00^{ab}
2:3:1	0.25	3.92^a	8.04^{ab}	0.29^{ab}	3.79^a	8.00^a
2:3:3	0.17	2.04^b	6.1^{ab}	0.17^{ab}	2.00^{ab}	6.04^{ab}
SE ±	0.10	0.57	0.90	0.10	0.60	0.90
LS	NS	*	*	*	*	*
Provenance						
Gujba	0.07^b	1.93^b	7.02	0.10^b	1.86^b	6.97
Yusufari	0.25^a	2.73^a	6.69	0.34^a	2.73^a	6.64
SE ±	0.10	0.30	0.45	0.10	0.30	0.50
NS	*	*	NS	*	*	NS
NS	NS	NS	NS	NS	NS	NS

Means followed by the same letters within a column are not significantly different. *= Significant at 5%. NS = not significant. SE± = Standard Error and M x P = interaction between mixture and provenance.

Table 6: Root Length of Gum Arabic Provenance as affected by Potting in the Nursery

Year/month	2017	2018
	Months after sowing August	Months after sowing August
Treatments	3	3
Potting Mixtures		
2:0:1	69.48^{ab}	69.50^{ab}
2:0:3	59.02^b	56.04^b
2:1:1	76.15^a	76.15^a
2:1:3	70.60^{ab}	71.08^{ab}
2:2:1	72.93^a	72.94^a
2:2:3	70.98^{ab}	70.93^{ab}
2:3:1	83.63^a	83.55^a
2:3:3	68.57^b	68.57^{ab}
SE ±	4.70	4.72
LS	*	*
Provenance		
Gujba	70.88	70.97
Yusufari	71.21	71.22
SE ±	2.30	2.40
LS	NS	NS
M x P	NS	NS

Means followed by the same letters within a column are not significantly different. SE± = Standard Error, *= Significant at 5%. NS = not significant and M x P interaction between mixture and provenance

CONCLUSION AND RECOMMENDATION

The study concluded that potting mixture 2:1:1 was most appropriate for morphological growth characters of gum arabic provenances. However, superior seedling growth performance was recorded for Gujba provenance in most of the sampling during the study period. Therefore, 2:1:1 is recommended for use by farmers in the study area for the production of Gun Arabic seedlings of Yusufari and Gujba Provenances.

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