COMPARATIVE PERFORMANCE OF GROWTH AND SURVIVAL STATUS OF DROUGHT RESISTANT TREE SPECIES AT DISTRICT KOHAT, KHYBER PAKHTUNKHWA, PAKISTAN

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ABSTRACT

Comparative study on height and survival of seven plant species planted in 2017 in hillside ditches under semi-arid conditions at Paya Muslimabad, District Kohat was carried out. Seven drought resistant tree species were planted in three replications on RCB design. After plantation in 2017 the survival and height data of each species were collected every year in June till 2020 and analysed statistically. *Acacia ampliceps* and *Acacia elata* gained maximum height than *Acacia nilotica, Zizyphus mauritiana, Acacia victoriae, Acacia catechu* and *Acacia stenophylla* Mean heights recorded for different species were not significantly different from each other. Maximum survival percentage (75%) was recorded for *Acacia catechu* followed by *Zizyphus mauritiana* (74%) and the lowest survival percentage (62%) was recorded for each *Acacia ampliceps* and *Acacia victoriae* in the final year 2020. The mean values of survival among the different species were not significantly different from each other.

INTRODUCTION

Afforestation refers to the human induced conversion of non-forest land through planting, seeding and/or human induced promotion of natural seed sources. Afforestation is an effective strategy which helps to conserve the soils on degraded land by reducing soil erosion (Oscar, 2001). It results in increasing soil organic matter, improve soil structure, serve as a carbon sink (Cornelis *et al*., 2002; Jackson *et al*., 2002). Afforestation can assist in nutrient cycling and provide habitat for wildlife by improving the landscape (Thomas, 2001; Franco *et al*., 2003). Global climate change may produce major shifts in the distribution of vegetation in future at an alarming rates, which are much rapid and extreme in arid and semiarid landscapes within the ecotones at the boundaries between ecosystems. (Allen and Breshears, 1998; Woodwell, 2002). Though, drought is the main constraint throughout the world in the establishment of vegetation

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particularly for trees, which often have a relatively low water-use efficiency (Schume *et al*., 2004), Wang *et al*., 2004; Zhao and Li, 2005).

The total area of Pakistan is 79.6 million ha, of which 88 percent is arid to semiarid. The ecologies of Khyber Pakhtunkhwa and Northern Areas are semi-arid to humid. By ecologies, 51.5 percent of total country area is arid, 36.9 percent is semi-arid, 5.4 percent is sub-humid and 6.2 percent is mixed. About 41 million hectares is solely arid including about 11 million hectares comprising deserts where mostly the climate is hyper-arid [PCRWR, 1999; Iqbal *et al*., 2000). In arid and semiarid conditions, mortality rate of seedlings and sapling is high during afforestation because they are subjected to different natural environmental condition than those in the nursery environment (Castro *et al*., 2002; Grossnickle, 2000). Mainly two factors are responsible which limits the growth and establishment of seedlings are (i) high temperature and (ii) water scarcity during summer droughts (Maestre *et al*., 2003). A number of studies has been carried out which investigated different techniques for the purpose of increasing seedlings survival which included irrigation in summer, artificial shade, large volume of holes with heavy machinery and the use of protective cloth (Maestre and Cortina, 2002). For the proper management of arid and semi-arid areas, alternative low-cost afforestation methods that ensure the survival of seedlings and have minimal environmental impact were needed (Eldridge *et al*., 2012; Benigno *et al*., 2013). However, more studies are needed to assess the effects of soil amendments in afforested areas under arid and semiarid climatic conditions.

This study assessed the comparative growth performance and survival status of different plant species in dry afforestation technique like hill sides ditches on the afforestation success in a semi-arid area of Paya Muslimabad in District Kohat. We hypothesized that, in a context of dry climatic conditions, which species of plant showed better performance in growth i.e. Height and survival in dry afforestation technique i.e. hill side ditches and contribute to afforestation success. The main objectives were to (i) to test the efficacy of dry afforestation technique in semi-arid areas, selection of suitable species and to suggest most promising drought resistant tree species for semi-arid zone of Khyber Pakhtunkhwa.

MATERIALS AND METHODS

Experimental site, soil amendment (Dry afforestation techniques) and afforestation

Experimental site for the dry afforestation techniques was established at Paya, Muslimabad, District Kohat which was geographically located at X: 33.449569 Y: 71.393873. The study area has an average elevation of 489

meters (1,607 ft) above sea level. It lies in a semi-arid climatic zone with very hot summers and mild winters. The mean maximum temperature in summer was over 40°C (104°F) and the mean minimum temperature during winter was 4°C (GOP, 2019). Rainfall in the research area ranges from 24 to 321 mm per month with the highest precipitation received in the months of July and August (GOP, 2019).

Plantation were raised on an area of 9.65 acres. Hill side ditches were constructed through tractor-driven ditcher on moderate slopes. Continuous ditches along the contour were made and plant pits with 60 cm diameter and 30 cm depth were excavated manually. The ditcher excavated 66 cm wide and 30 cm deep ditches with a 30 cm ridge on the downhill side. The excavated soil from the plant pit was placed in the ditch on one side of the pit to divert the runoff water to the pit. This was the cheapest water harvesting technique because of mechanization. The distance between plant to plant were kept 10 feet while the distance between row to row were kept 20 feet. Seven plants species were planted for testing in these sites with 3 replications (Fig.1).

The experimental site was cleared from natural vegetation to minimize competition for nutrients and space. The vegetation cover in the area was less than 30%. In August 2017, an afforestation plan was carried out in the experimental site following the same pattern of plantation in three replications.

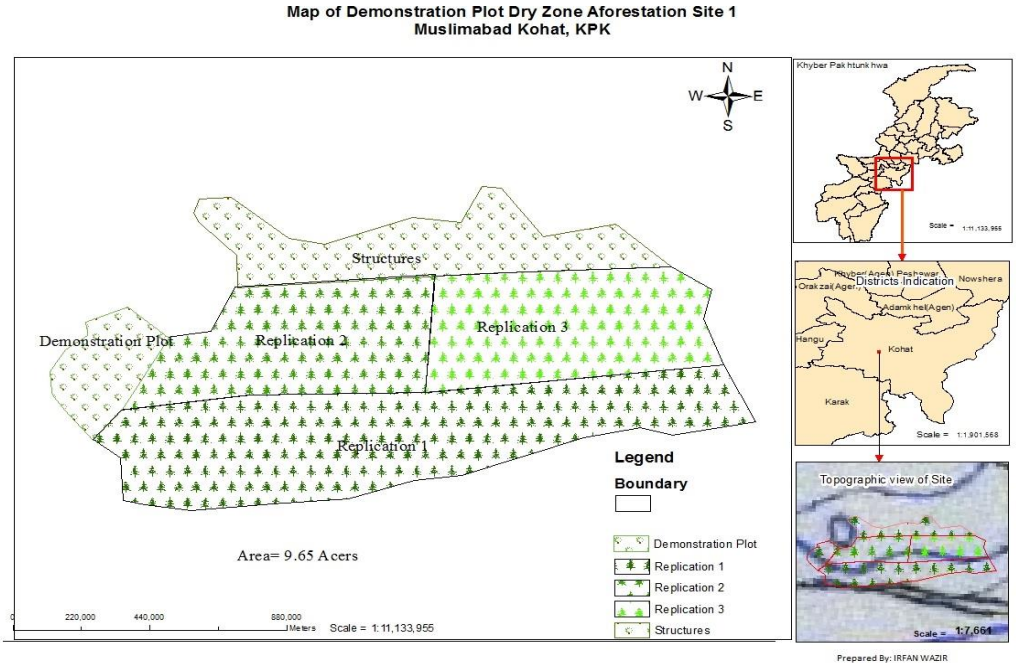

Fig.1. Map of the experimental site in Paya Muslimabad, District Kohat

Seedlings of suitable size adopted to the type of environment under the study were raised in the project nursery established at Pakistan Forest Institute, Peshawar. After gaining a suitable size the species were planted in the experimental sites. Seven species namely *Acacia nilotica* (cup), *Zizyphus mauritiana, Acacia victoriae, Acacia elata, Acacia catechu, Acacia stenophylla* and *Acacia ampliceps* were planted for testing in the experimental sites with 3 replications in hill side ditches.

Data collection and monitoring of vegetation

Seedlings were assessed once annually in the period 2017– 2020: (i) 11 months following afforestation (June 2018); (ii) 23 months following afforestation (June 2019); and (iii) 35 months following afforestation (June 2020). The final growth and survival percentage were compared with the initial data of height and survival percentage. This frequency enabled assessment of growth and development of the plants and survival during the dry and wet seasons. The number of surviving plants was determined during the field surveys, and the phenological state of plants was measured according to the criteria of Castro *et al.,* (2002) and Gomez-Aparicio *et al.,* (2004). A seedling was considered to be alive if living leaves, buds, or stems were observed. The plant height was measured from the ground to the terminal bud of the tallest stem.

Statistical analysis

The experiment was planned in Randomized Complete Block Design (RCBD) and means were compared using least significant difference test (LSD) (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Comparative Height study of Various Species

The result in Table 1 showed that the mean maximum growth in height was gained by *Acacia ampliceps* (2.0 ft) followed by *Acacia elata* (1.9) and the lowest (1.0) by *Acacia catechu.* The result showed that the mean height among the different plant species were not significantly different from each other.

The result also showed that mean height recorded for different plant species during different years were significantly different from each other.

It is clear from the table-1 that the growth in plant heights during different years after transplantation increased gradually year after the year in all types of plants in the research site. The increase in growth rate was minimum after first year i.e. in 2018 which gradually increased during the second year i.e. in 2019

and finally reached to maximum in the year 2020 in all types of plants. The decrease in growth rate during the first year may be due to the summer drought and low rainfall in the research area because establishment and development of roots by the saplings is minimum in the initial years due to which it could not tolerate stress of droughts resulted into low growth in heights (Bochet et al., 2007).

Table 1. Mean values of height of different plant species calculated after analysis using statistics 8.1 software two-way ANOVA (LSD) was used to test for significant differences (P<0.05) for marginal means of variables

S.No	Species	Mean Heights (ft)				Mean
		Initial Height	2018	2019	2020	
1	Acacia nilotica	0.8	1.1	1.0	1.7	1.2 cd
2	Zizyphus mauritiana	0.8	1.2	1.5	2	1.4 bc
3	Acacia victoriae	0.8	0.9	1.2	1.3	1.1 cd
4	Acacia elata	0.9	1.3	2.0	3.4	1.9 a
5	Acacia catechu	0.7	0.9	1	1.2	1.0 d
6	Acacia stenophylla	0.9	1.3	1.9	2.7	1.7 ab
7	Acacia ampliceps	0.6	1.5	2.3	3.4	2.0 a
Mean		0.8 d	1.2c	1.6b	2.2a	

Average values followed by the same letter are not significantly different at LSD 0.05.

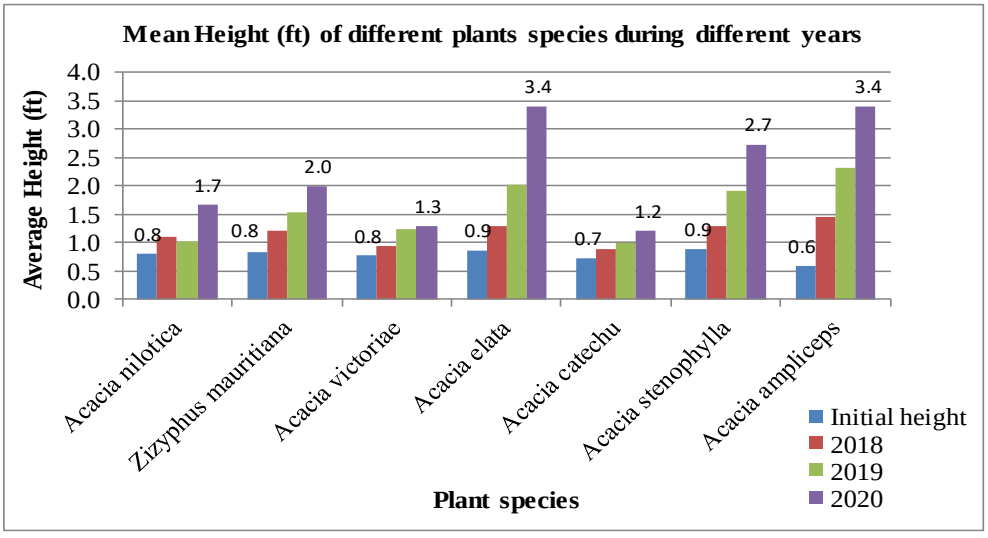

Fig. 2. Showing Mean Height (ft) of different plants species during different years

The result in Fig. 2 showed that all the plant species showed growth in height during different years i.e. the lowest heights were recorded in the initial years whereas the increase in heights of plants were recorded during the years 2018, 2019 and 2020 consecutively except in *Acacia nilotica* where the mean height in 2019 was less than the mean height in 2018. The initial heights (ft) recorded for *Acacia nilotica, Zizyphus mauritiana, Acacia victoriae, Acacia elata, Acacia catechu, Acacia stenophylla* and *Acacia ampliceps* were 0.8, 0.8, 0.8, 0.9,0.7,0.9 and 0.6 respectively whereas the final height in the year 2020 for these species were 1.7, 2.0, 1.3, 3.4, 1.2, 2.7 and 3.4 respectively. The result showed that highest growth in height was recorded in *Acacia ampliceps* followed by *Acacia elata* while the lowest height (1.2) was recorded in *Acacia catechu.*

Though a number of studies had been carried out on the comparative growth and survival of different species by using different afforestation techniques still little work has been previously carried out on the plant species used in this research. Siddiqui and Shah (1994) reported similar result while studying different planting techniques for the establishment of tree plantations in dry regions and found that maximum height was gained by *Acacia tortilis* (6.5 m) followed by *Acacia elata* (5.9 m). Similarly, Sardar (1992) also found that the growth rate of *A. albida* was highest amongst all the species which had attained average height of 1.3 meters in four years. Noor and Shah (1995) found that the average height gained by *Acacia tortilis* was highest when growth and biomass of five tree species planted in roaded catchment were studied at Dagarkotli in arid conditions.

Comparative Survival status of different species

The result in Table 2 showed that the maximum survival percentage was recorded for *Acacia catechu* (75%) followed by *Zizyphus mauritiana* with 74% survival whereas the lowest survival percentage was recorded for *Acacia ampliceps* and *Acacia victoriae.* The result showed that mean values of survival among the different plant species were not significantly different from each other.

The result also showed that survival percentage recorded for different plant species during different years were significantly different from each other.

It is clear from the table-2 that the survival percentage in the initial year was 100% and after first year in 2018 it was reduced to 84% which indicated that most mortality occurred during the first summer, e.g., between 6 and 12 months after plantation. This may be due to summer droughts and low rainfall during the summer season resulted in to the production of stress which may be responsible for the initial increase in plant mortality due to the limited root development of the saplings and their inability to access water contained in the lower layers of the soil profile (Maestre and Cortina, 2002). The result showed that the mortality rate

among all the plants species reduced gradually year after the year. This may be due to the establishment and development of roots by the saplings due to which it could tolerate stress of droughts.

Table 2. Survival Percentage of different plant species and their mean values calculated after analysis using statistics 8.1 software two-way ANOVA (LSD) was used to test for significant differences (P<0.05) for marginal means of variables

S.No	Species	Survival Percentage (%)				Mean
		2017	2018	2019	2020	
1	*Acacia nilotica*	100	86	74	69	82.0 ab
2	*Zizyphus mauritiana*	100	88	79	74	85.3 a
3	*Acacia victoriae*	100	84	71	62	79.3 ab
4	*Acacia elata*	100	84	73	64	80.4 ab
5	*Acacia catechu*	100	85	79	75	85.0 a
6	*Acacia stenophylla*	100	82	73	67	80.5 ab
7	*Acacia ampliceps*	100	83	70	62	78.8 b
Mean		**100a**	**84.6b**	**74.2c**	**67.6d**	

Average values followed by the same letter are not significantly different at LSD 0.05.

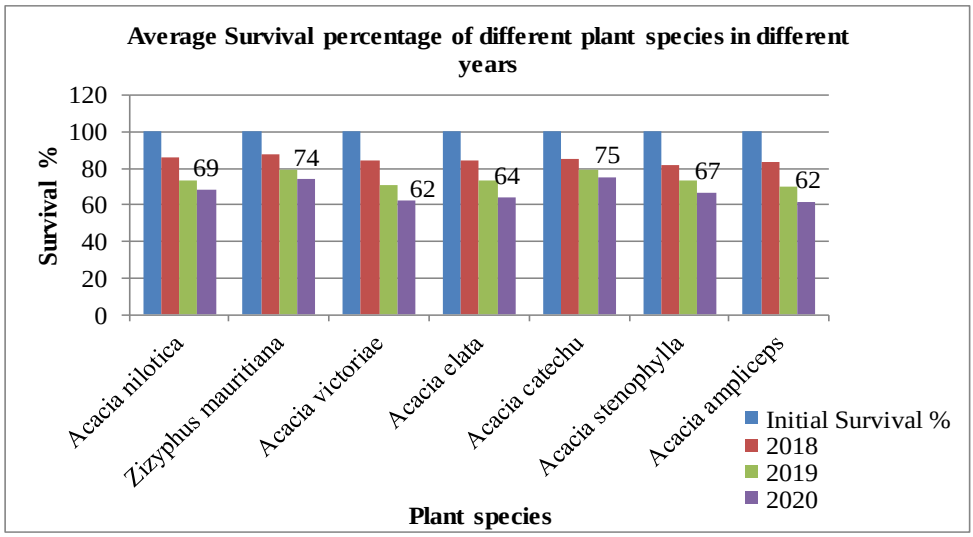

Fig. 3. Showing survival (%) of different plants species during different years

The result in Fig.1 showed that the initial survival percentage for all the plant species were 100%. Whereas the final survival percentage in the year 2020 recorded for *Acacia nilotica, Zizyphus mauritiana, Acacia victoriae, Acacia elata, Acacia catechu, Acacia stenophylla* and *Acacia ampliceps* were 69, 74, 62, 64, 75, 67 and 62 respectively. The result showed that the greatest survival percentage was recorded for *Acacia catechu* 75% followed by *Zizyphus mauritiana* 74% while the lowest survival percentage (62) for *Acacia victoriae.*

Sardar (1992) while studying the comparative status of growth and survival of different plant species found that the survival and establishment of *L. leucocephala* were highest followed by *A. albida* with survival percentage of 87% and 76% respectively.

CONCLUSIONS

Result of the study revealed that *Acacia ampliceps* and *Acacia elata* were promising high yield tree species for dry afforestation programmes in semi-arid environment although their survival percentage were minimum i.e. 62% and 64% respectively. *Acacia stenophylla* and *Zizyphus mauritianai* may be selected for plantation in mixture with *Acacia ampliceps* and *Acacia elata* because these are good fodder trees and have got positive effect on ground vegetation.

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