Productivity of Cowpea (*Vigna unguiculata* L. Walp.) as Influenced by Sowing Dates and Cutting Dates Under Salinity Soil Conditions

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Abstract

At El-Serw Agriculture Research Station, Damietta Governorate, Agricultural Research Center, Egypt, over the two succeeding summers of 2019 and 2020, two field experiments were undertaken. The experiment was done in a separate location "low and medium salinity soil and each location was consisted of three planting dates (15th March, 15th April and 15th May). In addition, cutting dates, i.e., (cuts were taken after 40, 50, and 60 days for each location) were distributed in a randomized complete block design (RCBD) inside the sowing date plots in every location with three replications. Results indicated that highest values of growth characters, total fresh and dry weigh per feddan (one feddan equal 4200 m^2) of cowpea were resulted under the low level of salinity soil (3.35 dSm^{-1} over both seasons) in both seasons in all studied sowing dates. Sowing cowpea on 15th May optimizing all studied seed characters. On the other hand, the lowest values of seed characters of cowpea were recorded due to early sowing date on 15th March in both growing seasons. Results also showed that, increasing number of days to cut cowpea forage up to 60 days increased productivity of cowpea under low and medium levels of soil salinity at the three studied sowing dates in both seasons. So, sowing cowpea on 15th of May and cutting plants every 60 days in order to maximizing productivity of cowpea under soil salinity stress to meet climate changes and environmental stress.

Keyword: Cowpea, sowing date, cutting date, salinity

إنتاجية للوبيا العلف تحت تأثير مواعيد الزراعة والحش تحت ظروف ملوحة التربة

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المستخلص

أجريت تجربتين حقليتين بمحطة بحوث السرو الزراعية بمحافظة دمياط، مركز البحوث الزراعية، مصر، خلال الموسمين 2019 و2020. أجريت التجربة في موقعين منفصلين "الأول تربة منخفضة والثاني متوسطة الملوحة" بغرض دراسة تأثير ثلاث مواعيد للزراعة (15 مارس، 15 أبريل و15 مايو)، وثلاث مواعيد للحش وهى (الحش بعد 40، 50، 60 يومًا لكل موقع) تم توزيع المعاملات تحت الدراسة لكل من الموقعين منفردين وتم زراعة كل ميعاد منفردا وتم توزيع مواعيد الحش في تصميم قطاعات كاملة العشوائية في ثلاث مكررات. أشارت النتائج إلى أن أعلى القيم لصفات النمو والوزن الغض والجاف للفدان نتجت تحت ظروف التربة متوسطة الملوحة (3.35 ديسيمتر مكعب) في كلا الموسمين. أظهرت النتائج أن مواعيد الزراعة كان لها تأثير معنوي على الصفات تحت الدراسة، أدى زراعة نباتات اللوبيا في 15 مايو إلى تحسن في جميع صفات البذور المدروسة. من ناحية أخرى، سجلت أقل القيم لصفات بذور اللوبيا نتيجة الزراعة المبكرة في 15 مارس في كلا موسمي النمو. كما أوضحت النتائج أن زيادة عدد أيام حش نباتات للوبيا العلف حتى 60 يومًا أدى إلى زيادة إنتاجية محصول العلف الغض والجاف تحت المستويات المنخفضة والمتوسطة من ملوحة التربة في مواعيد الزراعة الثلاثة المدروسة في كلا الموسمين. لذا توصى هذه الدراسة إلى زراعة نباتات للوبيا العلف في 15 مايو وحش النباتات كل 60 يومًا من أجل زيادة إنتاجية اللوبيا تحت ظروف ملوحة التربة لمواجهة التغيرات المناخية والإجهاد البيئية.

الكلمات المفتاحية: لوبيا العلف، مواعيد الزراعة، مواعيد الحش، الملوحة.

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Introduction

Most crops across the world have decreased yield as a result of salinity, an abiotic stress. Such stress reduces germination and causes uneven seedling emergence, which lowers population density and has an impact on crop establishment. On the other side, salinity is known to limit plant development, with the first stage being osmotic stress or water stress phase, which is brought on by a reduction in water intake in roots (Munns and Mechanisms, 2008). In this regard (Zahedi *et al.,* 2012) showed that all of the growth indices of cowpea usually decrease when the amount of salt increase, but cowpea seed can bear on this salt with density to 8 dSm^{-1}. (Gogile *et al.,* 2013) found that the quality, productivity, and vegetative development of cowpea productive seeds are adversely affected by saline stress. (Abdelgawad, 2014) mentioned that salinity at various levels was observed to induce a greater drop in yield and yield components of cowpea (number of pods/plant, yield/plant, and weight of 100 seeds). (Win and Oo, 2015) found that saline stress slows practically all elements of plant growth, including seed germination speed and percentage, plant vegetative features, photosynthetic pigment content, and the presence of several minerals in both plants and seeds. (Bashandy and El-Shaieny, 2016) pointed out that salinity is one of the major abiotic stress which seriously affect cowpea growth and yield production. (Neta, 2016) revealed that there is a residual effect of soil salinity on the physiological quality of produced seeds.

The timing and length of the vegetative and reproductive phases are significantly influenced by the sowing date since environmental elements like temperature and light alter according on the sowing date. Therefore, it is crucial to choose the date of planting for barley in order to achieve the optimum limits for these elements and obtain the best development and yields. In this regard, (Asante *et al.,* 2001) disclosed that the seeding date has a great impact on seed yield and quality of cowpea and effectively reduced the menace of insect pest damage on cowpea pods and invariably increased seed yield. (Lizaso *et al.,* 2018) indicated that the ideal sowing time would depend on the site, environment, and hybrid, but for areas with high summer temperatures (>30 °C), the sowing time should be coordinated to minimize the detrimental effects of high temperatures at flowering and at seed set, which negatively affects seed output.. (El-Sobky and Hassan, 2021) revealed that the late cowpea sowing on 30th June appeared to be produced the higher seed yield contributions and yields ha^{-1}, crop and harvest index as well as pure seed. (Nunes, 2021) reported that sowing cowpea in early April is appropriate for significantly improve final crop yields.

The quality and quantity of forage crops are affected by cutting schedules, which is a crucial agronomic activity. In order to restore the quality of the pasture, cutting management is also essential.

Cutting allows for crop regeneration and being able to tolerate cutting is a desired quality for effective herbage crop production since it lowers the cost of production in terms of seed and land preparation. (Mohamed and Khair, 2010).

Materials and Methods

Place and objective of the study:

Two field experiments were conducted at El-Serw Agriculture Research Station (It is situated at 31° 22' North latitude and 31° 64' East longitude), Damietta Governorate (North Delta), Egypt's Agricultural Research Center throughout the two succeeding summers of 2019 and 2020. These experiments' purpose was to investigate the effect of climate changes (expressed as sowing dates) and environmental stress (expressed as cutting dates and salinity soil conditions) on cowpea productivity and quality.

Experimental design and treatments

Cowpea was sown in two locations in El-Serw Agriculture Research Station, the first characterized as low salinity soil and the second characterized as medium salinity soil. Before conducting the experiment, soil samples from 0-30 cm depth were gathered and mixed from each location, air dried, grounded, sieved through a 2 mm sieve, and tested to determine the physical and chemical properties according to (Page, 1982). The soil physical and chemical properties of both locations during the two growing seasons were shown in Table 1. According to data in Table 1, averages soil salinity in the first location (low salinity soil "S1") were 3.50 and 3.20 dSm^{-1}, and averages soil salinity in the second location (medium salinity soil "S2") were 6.00 and 5.55 dSm^{-1} in the first and second seasons, respectively. The feature of water which used in irrigation was (EC 1.2:1.4 dSm^{-1}, SAR 10.5:11.3), so the irrigation water classification is considered to be water that increases salinity problems. In every location, cowpea was sown in three different sowing dates (15th March, 15th April and 15th May).

Where, each sowing date was performed in separate experiment, Using the dry technique (Afir), seeds were drilled 20 cm apart on hills 20 cm apart at a seeding rate of 20 kg/fed. Every experiment of sowing dates of cowpea forage crop and locations was carried out in randomized complete block design (RCBD) with three replicates.

Table 1. Soil physical and chemical properties of the investigated soils during 2019 and 2020 seasons

Locations	Low salinity soil (S_1)		Medium salinity soil (S_2)	
Soil properties	2019 season	2020 season	2019 season	2020 season
Particle size distribution (%):				
Coarse Sand	10.50	10.70	11.20	11.10
Fine Sand	11.50	11.30	14.10	14.60
Silt	20.50	20.50	16.20	16.30
Clay	57.50	57.50	58.50	58.00
Texture Class	Clayey	Clayey	Clayey	Clayey
Chemical properties:				
pH (1:2.5)	8.40	8.20	8.30	8.40
EC dSm^{-1}	3.50	3.20	6.00	5.55
OM %	0.98	0.88	0.75	0.72
Soluble Cations (meq 100 g^{-1}):				
Ca++	7.11	6.85	9.13	8.69
Mg^{++}	6.79	6.09	8.53	8.03
K^{+}	0.21	0.21	0.28	0.25
Na^{+}	18.5	17.86	38.35	35.08
Soluble Anions (meq 100 g^{-1}):				
CO_3^{-}	-	-	-	-
HCO_3^{--}	1.80	1.80	1.60	1.70
Cl^{-}	17.29	19.69	37.67	32.34
SO_4^{--}	13.52	9.52	17.02	18.01
Available Nutrients (mg kg soil $^{-1}$):				
Nitrogen (N)	32.00	32.00	33.00	34.00
Phosphorus (P)	8.40	8.42	6.60	6.61
Potassium (K)	450.00	465.00	450.00	452.00

Each sowing date experiment included three cutting dates (cuts were taken after 40, 50 and 60 days). After final cut the plants left for seed production in every location for the two crops. A total area of 5.40 m^2 was created by the three ridges that were part of each experimental unit. Each ridge was 60 cm wide and 3.0 m long. Egyptian clover (*Trifolium alexandrinum* L.), in both seasons, was the crop that came before the winter crop. The experimental field was well prepared through two ploughings, compaction, division and then divided into the experimental units with dimensions as previously mentioned. Calcium super phosphate (15.5 % P_2O_5) was applied at the rate of 200 kg/fed during soil preparation. The cultivation took place on the aforesaid sowing dates of cowpea (Balady genotype) at the rate of 20 kg/fed in the two growing seasons.

Studied characters

Growth traits: Before each cut of cowpea forage crop, five guarded plants were chosen at random from outer ridges of each plot to estimate the following characters: number of leaves/plant; total chlorophylls (SPAD): By using SPAD-502, the total chlorophyll content of flag leaf was determined (Minolta Co. Ltd., Osaka, Japan); leaf area index (LAI): it was calculated according to (Watson, 1958) formula:

$$LAI \frac{Leavea\ area\ per\ plant}{Plant\ ground\ area}$$

Plant height (cm); and stem diameter (cm).

Forage Yield: At each cut of cowpea forage crop, all plants in inner ridge of each plot were harvested to estimate the following yield characters: total fresh weight of forage in kg for each cut and its total were determined for each plot and turned to ton/fed. The sum of the total cuts was calculated to get the total cuts; Dry weight of forage in kg for each cut and its total, where 100 g plant representative samples from each plot were dried at 70 ºC for 24 hours and then to 105°C till constant weight and dry matter percentage (DM %) were estimated. Then dry forage yield was determined for each plot and weighed in kg/fed. The sum of the total cuts was estimated for the total cuts.

Seed characters: At the final cut of cowpea, five guarded plants were chosen at random from outer ridges of each plot to estimate the following seed characters: pod length (cm); pod weight (g); 100-seed weight (g): after threshing random sample of 100-seeds was taken from each plot, hand counted and weighted to record the mean seed weight; seed yield (g/plant): It was estimated by weighted all clean seeds per plant; seed yield (kg/fed): Whole plants were gathered from the inner ridge of each plot and allowed to dry on air before being threshed and the seeds (which were at 13% moisture) weighted (kg), then converted to kilos per feddan. Therefore, this study may be used to prove that applied sciences are highly significant in life because of their various applications in the present and in the past (Kandil *et al.,* 2014; Abido and Zsombik, 2018; Abido and Zsombik, 2019; Abido *et al.,* 2021).

Statistical analysis

Using the "MSTAT-C" computer software program, the collected data were statistically evaluated in accordance with the randomized complete block design (RCBD) approach for each experiment (sowing dates in each site), as defined by (Gomez and Gomez, 1984). The least significant difference (LSD) technique was used by (Snedecor and Cochran, 1980) to analyse the differences between treatment means at the 5% level of probability. The homogeneity of error variances was evaluated using Bartlett's test. Data from both seasons were not pooled because the test was significant for all attributes.

Results and Discussion

Growth characters:

Number of leaves plant^{-1}, total chlorophylls (SPAD), leaf area index (LAI), plant height (cm) and stem diameter (cm) as affected by salinity levels, sowing and cutting dates in various cuttings during 2019 and 2020 seasons are presented in Tables 2, 3, 4, 5 and 6, respectively. From obtained results of this study, it could be noticed that increasing salinity from low salinity level (3.35 dSm^{-1} over both seasons) to medium salinity level (5.77 dSm^{-1} over both seasons) as shown in Table 1, reduced the studied growth characters of cowpea *i.e.* leaves number plant^{-1}, total chlorophylls, LAI, plant height and stem diameter in the two growing seasons of 2019 and 2020. Where, the most numbers of leaves per plant, total chlorophylls, LAI, plant height and stem diameter were obtained from sowing cowpea

in low level of salinity soil (3.35 dSm^{-1} over both seasons). While, the lowest values of the studied growth characters of cowpea were produced from sowing cowpea in medium level of salinity soil (5.77 dSm^{-1} over both seasons). A combination of low osmotic potential of soil solution, nutritional imbalance, specific ion impact, hormonal imbalance, induction of oxidative stress, and hormonal imbalance may be to blame for the decline in growth characteristics of cowpea caused by increasing soil salinity levels. These findings are in strong accord with those made by (Zahedi *et al.,* 2012).

Sowing dates of cowpea *i.e.* 15th March, 15th April and 15th May had obvious effect on the studied growth characters of cowpea *i.e.* number of leaves/plant, total chlorophylls, LAI, plant height and stem diameter in 2019 and 2020 seasons as presented in Tables 2, 3, 4, 5 and 6, respectively. Sowing cowpea on 15th May as optimum sowing date markedly possess the most marked increases in all studied growth characters, in addition produced two cuttings in both seasons. Where, highest values of growth characters were obtained from sowing cowpea on 15th May in the first and second seasons. Sowing cowpea on 15th April ranked after sowing on 15th May, additionally produced two cuttings also in both seasons. This positive effect can be attributed to the favorable environmental circumstances at the time, which are crucial for the establishment and growth of cowpea plants.

The effect of cutting dates (after 40, 50 and 60 days) on growth characters of cowpea *i.e.* number of leaves/plant, total chlorophylls, LAI, plant height and stem diameter was varied from non-significant (NS), significant (*) and highly significant (**) in 2019 and 2020 growing seasons as shown from data revealed in Tables 2, 3, 4, 5 and 6, respectively. Where, number of leaves/plant, total chlorophylls, LAI, plant height and stem diameter were significantly or highly significantly affected by cutting dates in various cuttings when sown cowpea in low and medium level of soil salinity at the three studied sowing dates (15th March, 15th April and 15th May) in both growing seasons, except; number of leaves/plant in first cut in low and medium level of soil salinity at the second sowing date in the first season, first and second cut in low level of soil salinity in the first season and first cut in medium level of soil salinity at the third sowing date in the second season; total chlorophylls in second cut in medium level of soil salinity at the second sowing date in the first season; LAI in first cut in low level of soil salinity at the first sowing date in the first season; plant height in second cut in low level of soil salinity at the second sowing date in the first season and second cut in low and medium level of soil salinity at the third sowing date in the first season and stem diameter in second cut in low level of soil salinity and first cut in medium level of soil salinity at the first sowing date and second cut in medium level of soil salinity at the second sowing date in the first season. Overall in all cuttings, increasing number of days to cut cowpea forage from 40 to 50 and 60 days increased all studied growth character in low and medium levels of soil salinity at the three studied sowing dates in the first and second seasons. Wherever, the highest values of number of leaves/plant, total chlorophylls, LAI, plant height and stem diameter were produced from cutting cowpea forage every

60 days, followed by cutting cowpea forage every 50 days in all cuttings, in low and medium levels of soil salinity, at the three studied sowing dates in the first and second seasons. On the other hand, growth characters were produced from cutting cowpea forage every 40 days in all cuttings, in low and medium levels of soil salinity, at the three studied sowing dates in the first and second seasons. These results may be due to cutting date is a very important agronomic practice as it impacts on growth of herbage crops (Mohamed and Khair, 2010).

Forage Yield:

The averages of forage yield of cowpea *i.e.* total fresh and dry weight of cowpea forage per feddan as affected by salinity levels, sowing and cutting dates in various cuttings during 2019 and 2020 seasons are presented in Tables 7 and 8, respectively. It could be perceived that increasing salinity from low salinity level (3.35 dSm^{-1} over both seasons) to medium salinity level (5.77 dSm^{-1} over both seasons) as shown in Table 1, reduced total fresh and dry weight of cowpea forage per feddan in the two growing seasons of 2019 and 2020 (Tables 7 and 8). Wherever, the highest total fresh and dry weight of cowpea forage per feddan were obtained from sowing cowpea in low level of salinity soil (3.35 dSm^{-1} over both seasons) in the two growing seasons of this study. Whereas the lowest total fresh and dry weight of cowpea forage per feddan were produced from sowing cowpea in medium level of salinity soil (5.77 dSm^{-1} over both seasons). These results are in excellent concurrence with those established by (Munns, 2008; Bashandy and El-Shaieny, 2016).

From achieved results of this investigation, sowing dates of cowpea (15th March, 15th April and 15th May) had noticeable effect on total fresh and dry weight of cowpea forage per feddan in 2019 and 2020 seasons as presented in Tables 7 and 8, respectively. Sowing cowpea on 15th May as optimum sowing date markedly companied the most manifest increases in total fresh and dry weight of cowpea forage per feddan, additionally produced two cuttings only in both seasons. Anywhere, the highest total fresh and dry weight of cowpea forage per feddan were resulted from sowing cowpea on 15th May in the first and second seasons. however, sowing cowpea on 15th April ranked after sowing on 15th May, additionally produced two cuttings as well in both seasons. Whilst the lowest total fresh and dry weight of cowpea forage per feddan were recorded due to early sowing date of cowpea on 15th March, that produced three cuttings in both seasons. The sowing date significantly affects the production of herbage since it controls how growth, development, and any stress occur during the herbage's growth phase (Nunes *et al.,* 2021). As of attained results of this research, the effect of cutting dates (after 40, 50 and 60 days) on total fresh and dry weight of cowpea forage per feddan was diverse from non-significant (NS), significant (*) and highly significant (**) in 2019 and 2020 growing seasons as shown from data revealed in Tables 7 and 8, respectively. Where, total fresh and dry weight of cowpea forage per feddan were significantly or highly significantly affected by cutting dates in various cuttings when sown cowpea in low and medium level of soil salinity at the three studied sowing dates (15th March, 15th April

and 15th May) in both growing seasons, except; total fresh weight of cowpea forage per feddan in first cut in low level of soil salinity at the first sowing date in the second season only. Generally, in all cuttings, increasing number of days to cut cowpea forage from 40 to 50 and 60 days increased total fresh and dry weight of cowpea forage per feddan in low and medium levels of soil salinity at the three studied sowing dates in the first and second seasons. Everywhere, the highest values total fresh and dry weight of cowpea forage per feddan were produced from cutting cowpea forage every 60 days, followed by cutting cowpea forage every 50 days in all cuttings, in low and medium levels of soil salinity, at the three studied sowing dates in the first and second seasons. Conversely, the lowest total fresh and dry weight of cowpea forage per feddan were produced from cutting cowpea forage every 40 days in all cuttings, in low and medium levels of soil salinity, under different sowing date. These results are in harmony with those achieved by (Njarui and Wandera, 2004).

Seed characters:

The averages of cowpea seed characters *i.e.* pod length and weight, 100-seed weight, seed yield plant^{-1} and seed yield fed^{-1} as affected by salinity levels, sowing and cutting dates in various cuttings during 2019 and 2020 seasons are presented in Table 9. Seed characters were reduced as increasing salinity from low salinity level (3.35 dSm^{-1} over both seasons) to medium salinity level (5.77 dSm^{-1} over both seasons) as shown from obtained results of this study in the two growing seasons of 2019 and 2020 (Table 9). Where, the highest values of seed characters were obtained from sowing cowpea in low level of salinity soil (3.35 dSm^{-1} over both seasons) in the two growing seasons of this study in all studied sowing dates. Even as, the lowest values of seed characters were produced from sowing cowpea in medium level of salinity soil (5.77 dSm^{-1} over both seasons) in all studied sowing dates. These results in good agreement with those found by (Gogile *et al.,* 2013; Abdelgawad, 2014; Neta *et al.,* 2016). The effect of sowing dates of cowpea *i.e.* 15th March, 15th April and 15th May was observable on the studied seed characters of cowpea as presented in Table 9. Sowing cowpea on 15th May as optimum sowing date markedly banded the most marked increases in all studied seed characters in both seasons. Where, the highest values of length and weight, 100-seed weight, seed yield/plant and seed yield/fed were resulted from sowing cowpea on 15th May in both seasons. Sowing cowpea on 15th April ranked after sowing on 15th May regarding seed characters in both seasons. While, the lowest values of length and weight, 100-seed weight, seed yield/plant and seed yield/fed were recorded due to early sowing date of cowpea on 15th March in the first and second seasons. The suitable environmental conditions during sowing on 15th Help to prevent the detrimental effects of excessive temperatures during blooming and seed set, which have a negative impact on the characteristics of the seeds. (Lizaso *et al.,* 2018; El-Sobky and Hassan, 2021). The effect of cutting dates (after 40, 50 and 60 days) on seed characters of cowpea *i.e.* length and weight, 100-seed weight, seed yield plant^{-1} and seed yield fed^{-1} was varied from non-significant (NS) and significant in 2019 and 2020 seasons (Table 9). Highest values

of seed characters were produced from cutting plants every 60 days, followed by cutting every 50 days in all cuttings, in low and medium levels of soil salinity, at the three studied sowing dates in the first and second seasons. These results may be ascribed to take one or more herbage cuts from a seed crop can reduce seed yield.

Table 2. Averages number of leaves/plant of cowpea as affected by salinity levels, sowing and cutting dates in various cuttings during 2019 and 2020 seasons.

Treatments		2019 season			2020 season		
		Cuttings					
Salinity levels	Cutting dates	1st	2nd	3rd	1st	2nd	3rd
First sowing date (15th March)							
Low salinity soil	40 days	44.66	81.33	89.66	60.66	64.00	72.33
	50 days	60.33	88.00	96.66	68.00	69.66	91.66
	60 days	65.66	100.33	118.00	93.66	74.33	101.66
	LSD 0.05	8.36	7.71	2.28	4.62	2.03	5.84
Medium salinity soil	40 days	28.00	33.33		61.66	34.00	
	50 days	32.66	36.00		65.66	42.00	
	60 days	38.33	43.66		70.66	58.66	
	LSD 0.05	4.55	5.07		2.03	3.78	
Second sowing date (15th April)							
Low salinity soil	40 days	61.00	115.00		81.33	67.66	
	50 days	65.33	119.00		88.33	88.66	
	60 days	72.00	135.66		61.33	105.00	
	LSD 0.05	-	9.21		10.22	8.59	
Medium salinity soil	40 days	48.66	45.00		57.33	34.00	
	50 days	52.33	53.33		67.66	42.00	
	60 days	51.66	64.33		76.33	58.66	
	LSD 0.05	-	14.94		3.75	2.25	
Third sowing date (15th May)							
Low salinity soil	40 days	78.33	144.33		67.66	93.66	
	50 days	80.00	159.33		113.33	114.00	
	60 days	100.00	185.33		145.33	132.33	
	LSD 0.05	-	-		12.61	10.96	
Medium salinity soil	40 days	54.33	69.33		86.00	111.66	
	50 days	73.33	74.00		80.00	121.33	
	60 days	76.00	80.33		90.33	129.00	
	LSD 0.05	2.30	4.03		-	6.96	

Table 3. Averages of total chlorophylls (SPAD) in cowpea leaves as affected by salinity levels, sowing and cutting dates in various cuttings during 2019 and 2020 seasons

Treatments		2019 season			2020 season		
		Cuttings					
Salinity levels	Cutting dates	1st	2nd	3rd	1st	2nd	3rd
First sowing date (15th March)							
Low salinity soil	40 days	44.66	45.66	52.66	51.33	49.33	53.79
	50 days	57.00	56.33	54.66	54.33	46.66	55.84
	60 days	59.00	58.33	55.66	58.43	51.33	56.86
	LSD 0.05	4.43	4.21	2.49	3.04	2.75	2.54
Medium salinity soil	40 days	44.33	43.66		41.66	42.33	
	50 days	46.66	46.66		45.66	44.00	
	60 days	48.66	49.33		44.33	47.66	
	LSD 0.05	3.71	2.99		3.71	2.44	
Second sowing date (15th April)							
Low salinity soil	40 days	57.33	58.00		60.30	56.66	
	50 days	58.00	58.66		62.53	59.33	
	60 days	65.33	66.66		66.66	61.66	
	LSD 0.05	4.70	5.22		4.06	3.35	
Medium salinity soil	40 days	50.33	52.33		49.66	45.33	
	50 days	52.33	53.33		52.66	49.00	
	60 days	52.66	53.66		54.66	49.66	
	LSD 0.05	0.304	-		4.06	4.55	
Third sowing date (15th May)							
Low salinity soil	40 days	66.33	67.33		65.33	62.70	
	50 days	68.33	69.00		66.66	64.13	
	60 days	70.33	70.66		69.33	68.10	
	LSD 0.05	1.85	1.75		2.09	2.52	
Medium salinity soil	40 days	54.33	55.66		53.66	48.66	
	50 days	56.00	57.33		57.66	52.66	
	60 days	57.33	58.66		58.66	54.33	
	LSD 0.05	3.11	3.11		3.44	2.34	

Table 4. Averages of leaf area index (LAI) of cowpea as affected by salinity levels, sowing and cutting dates in various cuttings during 2019 and 2020 seasons

Treatments		2019 season			2020 season		
		Cuttings					
Salinity levels	Cutting dates	1st	2nd	3rd	1st	2nd	3rd
First sowing date (15th March)							
Low salinity soil	40 days	1.967	3.967	3.767	1.500	3.967	2.933
	50 days	2.000	4.133	4.000	1.833	4.033	3.233
	60 days	2.133	4.433	4.033	1.933	4.200	3.467
	LSD 0.05	-	0.398	0.322	0.185	0.144	0.117
Medium salinity soil	40 days	1.267	2.733		1.400	2.933	
	50 days	1.433	3.000		1.667	3.167	
	60 days	1.667	3.233		1.933	3.533	
	LSD 0.05	0.235	0.372		0.144	0.185	
Second sowing date (15th April)							
Low salinity soil	40 days	2.233	4.733		1.700	4.333	
	50 days	2.367	4.967		1.867	4.600	
	60 days	2.367	5.333		1.933	4.667	
	LSD 0.05	0.117	0.275		0.144	0.287	
Medium salinity soil	40 days	1.800	3.367		1.367	2.933	
	50 days	1.633	3.433		1.667	3.167	
	60 days	1.900	3.700		1.967	3.533	
	LSD 0.05	0.235	0.381		0.203	0.185	
Third sowing date (15th May)							
Low salinity soil	40 days	2.100	5.400		1.833	4.833	
	50 days	2.433	5.617		2.233	5.033	
	60 days	2.467	5.667		2.267	5.533	
	LSD 0.05	0.287	0.275		0.372	0.352	
Medium salinity soil	40 days	1.767	3.867		1.567	3.333	
	50 days	1.967	4.133		1.833	4.567	
	60 days	2.100	4.367		1.833	4.767	
	LSD 0.05	0.117	0.120		0.235	0.275	

Table 5. Averages of plant height (cm) of cowpea as affected by salinity levels, sowing and cutting dates in various cuttings during 2019 and 2020 seasons

Treatments		2019 season			2020 season		
		Cuttings					
Salinity levels	Cutting dates	1st	2nd	3rd	1st	2nd	3rd
First sowing date (15th March)							
Low salinity soil	40 days	47.00	44.66	48.33	47.33	51.33	50.66
	50 days	50.66	57.00	49.33	49.33	51.66	64.66
	60 days	54.00	59.00	59.00	50.66	45.66	67.66
	LSD 0.05	5.12	6.43	4.75	2.31	5.51	4.65
Medium salinity soil	40 days	37.66	32.00		33.33	35.66	
	50 days	38.00	35.66		35.66	38.66	
	60 days	40.00	37.66		36.00	41.33	
	LSD 0.05	2.75	2.75		1.20	1.17	
Second sowing date (15th April)							
Low salinity soil	40 days	55.00	63.33		52.33	49.00	
	50 days	56.00	63.00		46.00	50.66	
	60 days	57.00	69.33		51.66	55.66	
	LSD 0.05	2.03	-		4.38	3.69	
Medium salinity soil	40 days	43.33	39.33		29.66	35.66	
	50 days	44.00	40.33		32.66	38.66	
	60 days	44.33	43.66		37.00	41.33	
	LSD 0.05	0.97	1.17		2.23	1.17	
Third sowing date (15th May)							
Low salinity soil	40 days	59.66	70.00		49.66	45.33	
	50 days	62.00	71.00		56.33	56.66	
	60 days	63.33	76.00		58.00	62.33	
	LSD 0.05	3.81	-		10.08	9.07	
Medium salinity soil	40 days	45.66	49.66		33.66	54.33	
	50 days	46.00	50.33		39.00	54.66	
	60 days	48.33	51.00		40.33	58.66	
	LSD 0.05	1.32	-		1.44	3.11	

Table 6. Averages of stem diameter (cm) of cowpea as affected by salinity levels, sowing and cutting dates in various cuttings during 2019 and 2020 seasons

Treatments		2019 season			2020 season		
		Cuttings					
Salinity levels	Cutting dates	1st	2nd	3rd	1st	2nd	3rd
First sowing date (15th March)							
Low salinity soil	40 days	0.400	0.550	0.817	0.400	0.467	0.533
	50 days	0.467	0.550	0.917	0.500	0.473	0.600
	60 days	0.483	0.600	0.983	0.650	0.513	0.683
	LSD 0.05	0.102	-	0.058	0.052	0.042	0.058
Medium salinity soil	40 days	0.233	0.400		0.250	0.413	
	50 days	0.233	0.450		0.367	0.470	
	60 days	0.250	0.467		0.417	0.500	
	LSD 0.05	-	0.059		0.058	0.056	
Second sowing date (15th April)							
Low salinity soil	40 days	0.533	0.667		0.700	0.513	
	50 days	0.583	0.683		0.783	0.567	
	60 days	0.650	0.750		0.833	0.613	
	LSD 0.05	0.066	0.102		0.038	0.018	
Medium salinity soil	40 days	0.317	0.500		0.300	0.413	
	50 days	0.333	0.517		0.450	0.470	
	60 days	0.383	0.533		0.467	0.500	
	LSD 0.05	0.058	-		0.062	0.056	
Third sowing date (15th May)							
Low salinity soil	40 days	0.617	0.733		0.900	0.660	
	50 days	0.633	0.783		0.950	0.703	
	60 days	0.733	0.850		1.017	0.737	
	LSD 0.05	0.058	0.058		0.058	0.040	
Medium salinity soil	40 days	0.417	0.567		0.517	0.663	
	50 days	0.433	0.600		0.550	0.773	
	60 days	0.467	0.650		0.650	0.830	
	LSD 0.05	0.058	0.062		0.064	0.092	

Table 7. Total fresh weight of cowpea forage (ton/fed) as affected by salinity levels, sowing and cutting dates in various cuttings and its total during 2019 and 2020 seasons

Treatments		2019 season				2020 season			
		Cuttings							
Salinity levels	Cutting dates	1st	2nd	3rd	Total	1st	2nd	3rd	Total
First sowing date (15th March)									
Low salinity soil	40 days	4.633	4.833	4.133	13.59	5.167	4.567	6.200	15.934
	50 days	4.900	5.067	4.267	14.23	5.133	4.833	6.500	16.466
	60 days	5.200	6.567	4.833	16.60	5.500	5.267	7.067	17.834
	LSD 0.05	0.272	0.353	0.247	0.285	-	0.235	0.235	0.151
Medium salinity soil	40 days	3.500	3.833		7.333	3.333	3.933		7.300
	50 days	3.767	4.167		7.934	3.567	3.967		7.834
	60 days	4.333	4.400		8.733	3.967	4.267		7.900
	LSD 0.05	0.420	0.322		0.342	0.235	0.205		0.073
Second sowing date (15th April)									
Low salinity soil	40 days	5.500	6.800		12.30	5.433	5.300		10.733
	50 days	6.033	6.833		12.86	5.733	5.317		11.050
	60 days	6.267	7.117		13.384	6.233	5.700		11.933
	LSD 0.05	0.439	0.381		0.401	0.498	0.436		0.306
Medium salinity soil	40 days	4.333	4.367		8.700	3.700	3.933		7.633
	50 days	4.333	4.633		8.966	4.100	3.967		8.067
	60 days	4.600	4.660		9.260	4.300	4.267		8.576
	LSD 0.05	0.276	0.244		0.434	0.322	0.255		0.102
Third sowing date (15th May)									
Low salinity soil	40 days	6.600	7.500		14.10	6.567	5.267		11.834
	50 days	7.533	7.667		15.20	6.933	5.633		12.566
	60 days	7.600	8.100		15.70	7.400	5.900		13.300
	LSD 0.05	0.250	0.285		0.215	0.287	0.287		0.186
Medium salinity soil	40 days	4.967	4.933		9.900	3.767	4.933		8.700
	50 days	5.200	5.133		10.33	4.450	5.433		9.883
	60 days	5.333	5.333		10.66	4.700	5.800		10.500
	LSD 0.05	0.195	0.210		0.310	0.372	0.235		0.197

Table 8. Dry weight of cowpea forage (kg/fed) as affected by salinity levels, sowing and cutting dates in various cuttings and its total during 2019 and 2020 seasons

Treatments		2019 season				2020 season			
		Cuttings							
Salinity levels	Cutting dates	1st	2nd	3rd	Total	1st	2nd	3rd	Total
First sowing date (15th March)									
Low salinity soil	40 days	66.16	71.43	62.18	199.7	72.73	65.68	62.39	200.81
	50 days	70.89	76.73	65.21	212.8	73.87	69.39	71.35	214.63
	60 days	75.90	101.0	75.01	251.9	80.44	78.05	78.92	237.41
	LSD 0.05	6.83	6.25	6.43	6.50	8.42	2.49	6.42	5.77
Medium salinity soil	40 days	51.54	59.04		110.5	52.08	64.30		116.39
	50 days	56.23	65.49		121.7	54.88	66.74		121.62
	60 days	65.90	70.78		136.6	63.43	70.31		133.74
	LSD 0.05	6.16	7.43		9.78	7.73	6.68		10.81
Second sowing date (15th April)									
Low salinity soil	40 days	81.09	105.7		186.8	78.54	78.75		157.29
	50 days	90.33	108.1		198.4	84.81	81.27		166.09
	60 days	95.14	114.5		209.7	93.87	88.29		182.16
	F test	*	*		*	**	**		*
	LSD 0.05	5.86	6.11		6.65	7.55	5.09		4.21
Medium salinity soil	40 days	67.81	71.56		139.3	60.16	76.67		136.83
	50 days	71.48	77.48		148.9	65.71	83.10		148.81
	60 days	74.41	78.19		152.6	70.75	93.38		164.14
	LSD 0.05	4.97	3.24		2.73	4.61	5.30		3.29
Third sowing date (15th May)									
Low salinity soil	40 days	100.0	123.0		223.0	96.73	82.51		179.24
	50 days	115.8	127.5		243.4	105.3	89.78		195.14
	60 days	118.0	138.0		256.0	133.9	94.08		228.05
	LSD 0.05	3.52	3.65		3.02	5.72	5.71		3.80
Medium salinity soil	40 days	80.39	83.92		164.3	62.87	88.54		151.41
	50 days	85.82	88.55		174.3	74.69	99.15		173.84
	60 days	89.85	93.73		183.5	80.32	107.3		187.69
	LSD 0.05	3.25	3.54		4.12	6.32	5.13		3.81

Table 9. Averages of seed characters of cowpea as affected by salinity levels, sowing and cutting dates in the final cut during 2019 and 2020 seasons

Treatments		Seed characters									
		Pods length (cm)		Pods weight (g)		100-seed weight (g)		Seed yield (g/plant)		Seed yield (kg/fed)	
Salinity levels	Cutting dates	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
First sowing date (15th March)											
Low salinity soil	40 days	7.00	7.56	1.430	1.410	6.87	6.93	120.6	113.3	334.2	251.0
	50 days	5.66	6.76	1.523	1.500	9.59	9.53	167.3	163.6	328.6	312.0
	60 days	9.66	10.00	1.573	1.550	8.88	8.79	143.6	161.6	355.5	325.0
	LSD 0.05	1.23	0.81	NS	NS	0.95	0.85	NS	21.91	Ns	44.00
Medium salinity soil	40 days	5.00	5.00	1.280	1.260	6.97	6.97	124.6	124.6	146.8	146.8
	50 days	6.00	6.00	1.413	1.400	8.09	8.09	130.3	130.3	228.0	228.0
	60 days	6.33	6.33	1.523	1.500	8.65	8.65	132.6	132.6	242.4	242.4
	LSD 0.05	1.17	1.17	0.128	NS	1.77	1.77	NS	NS	16.37	15.03
Second sowing date (15th April)											
Low salinity soil	40 days	5.00	5.00	1.900	1.880	10.28	10.16	180.3	180.6	340.2	320.6
	50 days	7.33	7.66	1.917	1.890	10.49	10.68	195.3	187.0	351.3	335.3
	60 days	13.33	13.43	2.003	1.980	11.62	11.59	213.0	205.6	357.5	344.0
	LSD 0.05	4.99	3.32	NS	NS	NS	1.37	NS	NS	NS	14.40
Medium salinity soil	40 days	6.00	6.00	1.727	1.710	6.51	6.51	120.3	120.3	247.1	247.1
	50 days	6.66	6.66	1.780	1.760	9.02	9.02	147.0	147.0	263.3	263.3
	60 days	7.00	7.00	1.907	1.880	9.53	9.53	164.6	164.6	305.3	305.3
	LSD 0.05	NS	NS	0.117	NS	1.54	1.54	NS	NS	NS	NS
Third sowing date (15th May)											
Low salinity soil	40 days	6.00	6.00	1.180	1.170	11.66	11.34	169.3	160.6	408.2	352.3
	50 days	6.33	6.66	1.910	1.890	12.02	11.63	218.6	194.3	421.7	360.0
	60 days	8.33	7.00	2.340	2.310	18.23	17.96	225.3	220.6	425.5	369.6
	LSD 0.05	2.35	NS	0.409	NS	2.12	1.14	37.91	30.57	NS	NS
Medium salinity soil	40 days	6.00	6.00	1.687	1.670	8.22	4.90	120.6	120.6	289.1	280.0
	50 days	6.66	6.66	1.787	1.770	8.63	5.44	136.3	136.3	302.6	343.5
	60 days	7.00	7.00	1.847	1.820	8.98	6.11	157.0	158.2	305.3	372.4
	LSD 0.05	1.17	1.17	0.050	NS	0.31	NS	17.92	15.62	NS	14.99

Conclusion

It is inferred that that sowing cowpea plants on 15th May and cutting forage every 60 days in order to obtain highest growth, total fresh and dry weight of forage and seed characters under soil salinity stress to meet climate changes and environmental stress under the environmental conditions of North Delta, Egypt.

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