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DETERMINATION OF CRITICAL LIMIT OF Fe IN SOIL FOR PREDICTING RESPONSE OF SORGHUM TO Fe APPLICATION IN ARIDISOLS

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ABSTRACT

Mean yield of sorghum shoot studied in 18 aridisols was observed to increase by 19 per cent in response to the application of 10 ppm Fe over control. A response of more than 20 per cent was obtained in 54.5 per cent soils. A highly significant positive relationship was obtained between Bray's per cent yield and DTPA extractable Fe. A critical limit of 4.5 ppm DTPA extractable Fe was established to separate Fe responsive soils from non-responsive ones.

INTRODUCTION

Occurrence of Fe chlorosis is common in crops grown on calcareous soils (Olson and Carlson, 1950). Very little work has been done to establish critical limits of Fe in soils for crops. For want of information on the critical limit, it is difficult to delineate areas of Fe deficiency and sufficiency for Indian soils. The present study was undertaken to determine critical limit of DTPA extractable Fe for sorghum in aridisols of Haryana.

MATERIAL AND METHODS

Eighteen bulk soil samples from the surface layer (0-15 cm) were collected from different sites from arid region of Haryana (India). The soils were air dried, crushed with a wooden mallet and passed through a 2 mm stainless steel sieve. The experiment was conducted in polythene lined earthen pots under screen house conditions. Each pot contained 4 kg soil. A basal dose of N, P, K, and Zn @ 100, 50, 50 and 5 ppm, respectively, was applied as reagent grade urea, $(NH_4)_2 PO_4$, KCl and $ZnSO_4 . 7H_2O$ in solution form. The treatments comprised three levels of Fe viz. O, 10, and 20 ppm Fe as $Fe SO_4 . 7H_2O$ in three replications. Sorghum cv HC-136 was grown for 45 days and after harvesting, washed in acidified deionized water and rinsed several times with deionized and glass distilled water. Plants were dried in an oven at 65°C and the dry matter yield was recorded. The soils were analysed for initial DTPA extractable Fe as described by Lindsay and Norvell (1978) and analysed by Atomic Absorption Spectrophotometry. The physicochemical characteristics of soil were determined by the procedures described by Chopra and Kanwar (1976).

The critical limit of Fe in soil was determined by plotting the Bray's per cent yield against available soil Fe. According to this proccdure two lines, one parallel to

the X-axis and the other parallel to the Y-axis, are drawn so that there are minimum number of observations in the upper left - hand and the lower right - hand quadrants. The intersection of the line parallel to the Y-axis with the X-axis is the critical limit (Cate and Nelson 1965). The Bray's per cent yield was calculated as:

$$\frac{\text{Yield without Fe application}}{\text{Yield with 10 ppm Fe application}} \times 100$$

RESULTS AND DISCUSSION

The soils were sandy to sandy loam, having pH 7.4 to 8.8. The free $CaCO_3$, EC (mmhos/cm), OC%, and DTPA extractable Fe ranged from 0 to 6.5%, 0.08 to 0.85, 0,12 to 0.55 and 1.4 to 6.4 ppm, respectively. In these soils Bray's pre cent yield ranged from 63.9 to 99.7 and was positively correlated with DTPA-extractable Fe.

Response to Fe

Data (Table 1) revealed that mean dry matter yield of sorghum shoot ranged between 4.58 to 9.17 g/pot. Application of 10 ppm Fe markedly improved the shoot

Table 1. Effect of Fe application on yield and Bray's per cent yield of sorghum in aridisols

Fe levels (ppm)				DTPA Fe,	Bray's per cent
0	10	20	mean	ppm	yield
		Shoot dry matter yield (g/pot)			
5.67	7.03	7.30	6.67	3.2	80.6
7.60	9.17	9.15	8.64	3.6	82.8
4.49	6.48	5.57	5.51	2.8	69.2
7.47	8.12	8.22	7.94	4.8	91.9
4.32	4.59	4.58	4.50	6.4	94.1
6.84	8.20	8.06	7.70	3.6	83.4
3.85	7.14	8.30	6.43	2.8	63.9
5.40	6.83	6.36	6.20	4.4	79.0
4.35	5.58	4.97	4.97	2.6	77.9
5.75	8.94	8.13	7.61	1.4	64.3
6.58	8.73	8.13	7.81	4.0	75.3
7.85	7.85	8.02	7.90	6.4	99.7
8.09	8.18	8.33	8.20	6.0	98.8
3.75	4.35	5.63	4.58	3.8	86.2
8.75	9.42	8.70	8.96	5.6	92.8
6.48	7.03	6.95	6.82	5.6	92.1
6.99	7.50	7.43	7.31	3.2	93.2
9.03	9.45	9.02	9.17	5.2	95.5
Mean 6.29	7.47	7.38			

Female reproductive organs

The camel has bicornuate - T shaped uterus, reddish, smooth and shiny in appearance and weighing 193 to 376 g (Shalash, 1965). The left horn is larger than the right (Joshi et al., 1978). In the Bactrian camel, the left horn has been reported to be 8-12 cm. and the right horn 6-8 cm. long (Chen and Yuen, 1979). The length from fundus to anterior end of the cervix is 8.5-9.5 cm and width in its middle part is 4.5 to 5.5 cm. The placenta is of diffused, epithelio-chorial type (Novoa, 1970). The smooth uterine mucous membrane is devoid of cotyledons.

The cervical canal is short, about 3.5 cm long and 5.5 cm in dia. The reddish vagina, 25-35 cm long, has mucosal folds posterior to the cervical opening. The vulva about 6-8 cm long, has urethral orifice on the top. The vulvar cleft is a short slit 4.5 to 6.5 cm in height, and the clitoris is very small.

The ovaries (average size 13 x 29 x 33 mm) weigh about 10 g (Chahrasbi et al., 1975). Shalash (1965), however, reported the weight of ovaries to vary from 3.66 to 8.50 g. Chen and Yuen (1979) observed that in the Bactrian camel the length, width and thickness for left ovary were 3.2 - 3.5 cm, 2.1 to 2.5 cm and 0.8 - 1.4 cm, respectively and for right ovary to be 2.8 - 3.5 cm, 2.2 - 3.0 and 0.6 - 1.2 cm, respectively. Abdo et al. (1969) reported the graffian follicles randomly distributed on the ovarian surface, larger in the left ovary than in the right ovary.

Musa and Abusineina (1978) observed that follicles generally take about 6 days to grow to 1.5 to 3 cm in size and remain constant for 5-19 days before regression which takes about 7-10 days. The growth of follicles alternates between the two gonads. Musa and Abusineina (1978) observed no luteal phase but such phase was described by Abdo et al. (1969).

Almost 95-99% pregnancies in the camels have been reported in left horn (Shalash, 1965; Musa and Abusineina, 1978), although, ovum could come from either ovary. The left ovary is more active than the right one. Twins or multiple births are almost entirely absent in this species.

Oestrus cycle and ovulation

According to Williamson and Payne (1978), the females become sexually mature at the age of about 3-4 years, first calving takes place at the age of 5 years and subsequent calvings are biennial. The females remain sexually active upto 20 years of age (Cossin, 1971). At Bikaner, a female more than 25 years of age produced a normal healthy calf. The female remains receptive to the male for 3-4 days at a time followed by 10-12 days of anestrus (Joshi et al., 1978). Usually, oestrus is exhibited five times in a breeding season (Gupta et al., 1978). Novoa (1970), however, stated that the sexual activity in camelids is acyclic and that ovulation is induced by copulation.

Chen et al. (1980) reported that in Bactrian camels, females exhibit continuous follicular cycles till successfully mated; follicles require 19.10 ± 4.25 days to develop and regress one after the other. The next follicle starts developing within 3-5 days of initiation of regression of the previous follicle and, therefore, one mature or developing follicle is usually always present in the breeding season unless the animals has mated. Unmated famale manifests prolonged period of oestrus (Chen & Yuen, 1979). Yagil (1982) reported that peaks of hormonal activities were quite regular and found to be about 28 days apart. The usual signs of oestrus are restlessness and aggressive behaviour of females. The tail is raised and animal urinates frequently. The female in heat mounts the other females. The vagina at this stage is reddish and moist (Yagil, 1985). The cervix is also moist and relaxed Musa, 1979). In the normal cycle the progesterone levels were assayed to be below 1 ng/ml, however, Yagil (1982) reported an increase in the level of this hormone after coitus.

The ovulation follows 36-48 hours after mating (Chen et al., 1980). Elias et al. (1984, a and b) reported that serum concentration of oestradiol varied between 9 and 110 pg/ml during the oestrus cycle and the concentration of progesterone exceeded 1 ng/ml only when the mating was fertile. Musa and Abusineina (1978) also observed that ovulation in dromedaries was not spontaneous and required coital stimulus. Manual stimulation did not induce ovulation. Similar observations were also made by Shalash and Nawito (1964). Chen et al. (1980; 1985) observed that ovulation could be induced in camels by inseminating seminal plasma but not the sperms. Most of the females ovulated by 48 hors after natural service. The amount of semen required was 1.0 ml. Injections of Luteinizing Hormone (LH), Human Chorionic Gonadotrophin (HCG) and Luteinizing Hormone Releasing Hormone (LHRH) also caused ovulation even in those females who did not ovulate in response to insemination.

Puberty and sexual maturity

The sexual maturity in the females of dromedary is attained at the age of 3-4 years (Mathaıu, 1966; Williamson and Payne, 1978). Leupold (1968) also reported that the sexual maturity is attained in both the sexes after 3 years. In the Iranian camels sexual maturity is attained at the age of 5 years (Khetami, 1970). Spencer (1973) opined that camels generally reach the age of 6 years before getting first calf. The attainment of sexual maturity is greatly influenced by factors like management, nutrition, breed etc. At Bikaner, the age at first service and age at first calving was found to be 1387.14 and 1882.38 days, respectively. The data were based on 60 and 93 observations over a period of eleven years. In Bikaneri males, although sexual desire was observed from 3-4 years of age but the normal rutting was observed only at the age of 5-6 years. Attainment of puberty is influenced by the overall growth and weight of the animal. Yagil and Etzion (1984) advanced the first oestrous in prepubertal camels (1½ to 2 years of age) by injecting FSH hormones. Injections resulted

in rise in oestrogen level in the experimental animals, follicular development and successful mating. Healthy calves were reported to have born after a normal partus. In similar experiments with Bikaneri heifers (aged 2-3 years), successful mating was achieved by hormonal treatments.

Fertility

The animals are not fit for breeding after 20 years of age (Leese, 1927). In exceptional cases animals even beyond 25 years of age have given birth to healthy calves (Cossin, 1971). At the Bikaneri camel farm, also, a female aged 25 years produced a normal healthy calf.

The camels reproductive life varies according to plane of nutrition, management, health and genetic factors. Dahl and Hjort (1976) opined that improved management conditions are very unlikely to increase the fertility rate in camels above 50%. Keikin (1976) reported that calving rate at a Soviet camel ranch was averaging only 40%. Bremaud (1969) estimated fertility rates in Gabbra and Somali camels as 34% and 52.25%, respectively.

Watson (1969) also reported 41% fertility rate and indicated that 80% animals had a calving interval of at least 2 years and 73% did not rebreed within 12 months of calving. The calving rate of Bikaneri camel during 1959 to 1984 (calves born as percentage of total reproductive femals present each year) ranged from 9.82 to 60% (av 39.2). The wide year to year variations were due to inconsistent management in different years. The calving rates during the year 1985 and 1986 were 35.38% and 51.47% respectively. The maximum calving was during January, followed by February March, December, April, May and November.

Yuzlikaev and Akmediev (1965) ascribed the low fertility in camel to non-developing follicles, embryonic mortality and abnormal anatomical features of mother (Novoa, 1970; Shalash, 1965). Unplanned breeding, malnutrition and poor management practices also result in low calving rate. Cossin (1971) and Yagil and Etzion (1984) obtained better fertility rates with improved management practices. Wilson (1984) reported calving rate of Darfur camels in Sudan to be 70%. Late age at first calving, limited breeding season and opportunity, prolonged calving interval, low plane of nutrition, poor management practices, diseases and, frequent perinatal losses (Mukasa-Mugerwa, 1981) are the factors affecting herd growth in camels.

Musa and Abusineina (1976) observed two or three corpora lutea in 13.65% and 1.22% of 491 single births, whereas twining rate was only 0.4%. Leese (1927) regarded that twins or triplets were never born to a camel. Shalash (1965) indicated early occurrence of embryonic mortality. Burgemeister (1974) pointed inbreeding as cause of low fertility in camels. According to Mukasa-Mugerwa (1981) common factors for low fertility in camels are early embryonic resorption, abortions and still

births. High abortion rate (Droandi, 1936) is due to trypanosomiasis, camel pox, pasteurellosis, salmonellosis and brucellosis (Richard, 1976; Fazil, 1977; Curasson, 1947 and Leese 1927). Diseases of reproductive organs also cause low herd growth (Spencer, 1973; Shalash, 1965, Roberts 1971). Newborn camel is very delicate and high losses occur in first 3 weeks of life (Williamson and Payne, 1978). Calf mortality in camels has variously been reported and estimated to be 50% (Leonard, 1984). However, to be 30-50% (Bremaud, 1969) and 31-59% (Cossin, 1971). Curasson (1947) reported 26% mortality in young calves upto 2 months of age. Field (1979) found 45% mortality in Kenya to be of the animals under 2 years. Lusigi (1984) reported 40% mortality in the first two years after birth in camels in a province in Kenya and only about 58% of all animals born reached sexual maturity.

Rutting in male camels

In India rutting in male camels is limited to the months of October to March and in some males, upto April. During rutting season the testes weigh heaviest (Charnot, 1963) and the level of spermatozoa in the epididymis reach maximum (Charnot, 1964 and Volcami, 1953). The level of circulating testosterone (Yagil and Etzion, 1980) has been reported to be higher in camels than that in bulls or men. Aggarwal et al. (1987) reported higher level of testosterone during breeding season in camels. Khan and Kohli (1978) reported statistically significant drop in blood haemoglobin and increase in total leucocytes during breeding season. The serum levels of both thyroxine (T4) and tri-iodothyroxine (T3) were found to be significantly higher during non-breeding season but T4 : T3 ratio was almost double during rutting season (Aggarwal et al., 1986). Behavioural changes like aggressiveness, making territory, placing urine on the back, restlessness, loss of appetite and weight loss are the main signs of rutting. There is copious secretion from poll (occipital) gland (Charnot, 1963). The secretion is dark brown with acrid smell and androgens are present (Yagil and Etzion, 1980). Anatomical, histological, histochemical and morphological changes in poll gland during breeding and non-breeding season were reported by Singh and Bharadwaj (1978c). Tingari et al. (1984) confirmed that histologically the poll gland resembles endocrine gland. The secretion of the poll gland attracts females during breeding season (Yagil and Etzion, 1980).

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Ideal ratios of male to females during breeding season are variously stated to be 1 male to 5-7 females (Watson, 1969) and 1 male to 50-80 females (Williamson and Payne, 1978; Singh, 1963 and Leupold, 1968). One camel stallion can breed three females per day at the peak of the breeding season (Burgemeister, 1975) subject to good management and health. We recommed a ratio of 1 male to 20-25 females. Keeping extra males is desirable to provide genetic diversity and to check inbreeding for wider and efficient selection.

Mating

The sexual behaviour of male Bikaneri camel was studied by Khan (1971). The copulation in camel starts with necking and courtship. The male smells the female's genitalia and may occasionally bite her. The male grinds teeth, expands soft palate into baloon, froths out saliva and makes gurgling sound; it induces the female into sitting position, grasps her with fore-legs while his weight is rested on hind legs and buttocks. Animals thus face the same direction and mate in sequatting position. During coitus the female makes peculiar bleating sounds.

The penis makes rotating movements on longitudinal axis during entrance. The copulation in Bikaneri camels may last for 2 to 18 minutes (av 4.56 minutes) varying according to season, status of rut and frequency of mating. Rakhimzhanov (1975) reported the duration of copulation for bactrian camel to be 12.15 $\pm$ 9.4 minutes.

Males may ejaculate three or four times (Mukasa-Mugerwa, 1981). In organised herds camel-men may provide aid for entrance of the penis into female genitalia.

Khan and Kohli (1972) reported the volume of semen discharged in Bikaneri camel to be 1-10 ml (av. 3.1 ml) using aritificial boar vagina. Chen and Yuen (1979) reported semen ejaculate of Bactrian male to be 1-7 ml (av 4.3 ml) with a spermatozoa count of 615 million per ml. The volume and percentage of spermatozoa showed progressive improvement during subsequent ejaculates. The semen is white in colour with thick viscid consistency, pH 7 (range 7.2-8.8). After copulation the male slips aside the female before standing.

Gestation period

The gestation period of the dromedary has been reported to range from 355-389 days (Burgemeister, 1975 and Williamson and Payne, 1978). Dahl and Hjort (1976) reported gestation period in Bactrian canel averaging 13.5 months. Breeding and parturition occur in the same season. The average gestation period in Bikaneri camel has been calculated to be 388 days for male calves and 389 days for female calves. These results are based on 532 observations. Comparable figures (390 $\pm$ 2 days) have been reported by Joshi et al. (1978).

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