RESULTS

R E S U L T S

SUNFLOWER

Morphological behaviour

1. The length of Roots :

In monsoon the roots of Sunflower showed a length of 11.3 cm by the 15th day and it registered the maximum rate of extension growth by the 30th day (Table 2 A). Thereafter the rate decreased though the roots showed a gradual increase in length and reached a maximum of 22.9 cm by 105th day. The treatment with fertilizers (FYM, NPK and a combination of both) did not bring about any marked effect on the length of root on 15th day. However, on 30th day treatment with mineral fertilizers alone or in combination with FYM favoured the growth of root as compared to control and that with FYM. This effect was observed throughout the growth period. The pattern of growth of root was found to be the same in winter and summer (Tables3 A and 4 A). It is observed that the growth of root was maximum in winter, followed by summer and monsoon.

2. The length of Stem :

In monsoon the rate of increase in length of the stem was fast till 45th day (Averg. 2.8 cm/day) (Tables 2 A, 3 A,

4 A; Fig. 2 B) then it declined (0.5 cm/day) till 60th day and thereafter the increase was only less than 0.5 cm per day. The length of stem was the highest in summer followed by winter.

3. Root/Shoot Length Ratio :

In monsoon during the early stage of growth of the plant the root/shoot ratio was found to be the maximum on the 15th day and thereafter this ratio showed a gradual reduction till 60th day and remained almost constant till the final harvest (Tables 2 A, 3 A and 4 A). This trend was noticed in the other two seasons also. The root/shoot ratio, in the early stage of growth was the highest in summer and the lowest in winter. The treatment did not show any consistant effect on root/shoot length ratio.

4. The number of green leaves per plant :

In all the three seasons the total number of leaves on 15th day did not vary much. The maximum number of leaves per plant, during monsoon, winter and summer was recorded on the 30th, 60th and 45th day respectively (Tables 2 A, 3 A and 4 A). Thereafter the number of leaves gradually decreased till the final harvest. The decrease in number of leaves was more pronounced in monsoon.

5. Average area (cm^2) per leaf :

The area per leaf increased with increase in age upto

the 60th day (except in control and FYM treated plants of monsoon, which showed maximum area per individual leaf on 75th day) (Table 2 A). The average area per leaf after registering the highest value decreased towards the final harvest. Plants treated with mineral fertilizers (Treatment-1 (NPK + FYM) and Treatment-2 (NPK)) produced bigger leaves as compared to those under control and those under treatment with FYM. Among the seasons mean area per leaf was highest during monsoon (Tables 2 A, 3 A, 4 A).

6. Total leaf area per plant ($cm^2.plant^{-1}$) :

The total leaf area per plant steadily increased from 15th day and registered the peak on 45th day during monsoon and on 60th day during winter and summer (except in the plants under control and the ones under treatment with FYM in winter) and decreased thereafter (Table 2 A). Among the different treatments, the one with a combination of FYM and NPK resulted in the production of maximum total leaf area per plant. This trend was observed in all the three seasons. The maximum leaf area was found in summer and the minimum in monsoon (Tables 3 A, 4 A; Fig. 2 A).

Functional behaviour :

Total biomass ($g.plant^{-1}$) :

All treatments gave higher accumulation of dry matter in

all seasons as compared to control (Tables 2 B, 3 B and 4 B; Fig. 5 B). In monsoon the biomass production under Treatment-2 (NPK) was higher till 60th day. The plants began to show differential response to treatments by 15th day in monsoon whereas in winter and summer the differential response was apparent from 60th day. In the final harvest the highest yield of biomass was observed under the influence of the combined application of fertilizers (Treatment-1 (NPK + FYM)) in all seasons followed by T-2 (NPK) and T-3 (FYM). Among the different seasons, the maximum production of total biomass per plant was observed in summer and the minimum in monsoon.

The root/shoot weight ratio :

In monsoon the root/shoot weight ratio was higher on 15th day and it decreased during 30th and 45th days(Table 2 B). Further it showed an increase on 60th day and thereafter gradually decreased. The same trend was observed in the other two seasons also except in two treatments (Treatment-3 (FYM) and Treatment-4 (Control)) in which the second peak was observed on 75th day in winter (Tables 3 B and 4 B).

Chlorophyll Content ($mg.g^{-1}$ fresh weight of leaves) :

Chlorophyll content did not show any appreciable difference after 15th day, between treatments and control (Tables 2 B, 3 B and 4 B).

Head Diameter (cm) :

The application of fertilizers enhanced the size of the head (diameter) in all seasons (Tables 2 B1, 3 B1 and 4 B1; Fig. 4). The size of the head varied from treatment to treatment and also from season to season. In monsoon the application of NPK resulted in the highest size of the head. But in winter larger heads were obtained from plants treated with the combined application of fertilizers (T-1 (NPK + FYM)) whereas in summer there was no appreciable difference between T-1 (NPK + FYM) and T-2 (NPK).

Number of Seeds per head :

With respect to this parameter the same trend as observed in the case of the size of the head was observed (Tables 2 B1, 3 B1 and 4 B1; Fig. 4). In monsoon there was no great difference in the number of seeds produced per head under different treatments. However, during winter all treatments increased the production of seeds per head. Among the treatments Treatment-1 (NPK + FYM) gave the highest number of seeds per head. In summer the trend was the same as that observed in monsoon, showing no remarkable difference due to treatments.

Weight of Seeds per head (g) :

The same trend, as that in the case of number of seeds

TABLE 2 B 1 - SUNFLOWER - FUNCTIONAL BEHAVIOUR

SEASON : MONSOON

PARAMETERS	TREATMENTS			
	T_1	T_2	T_3	T_4
Head diameter (cm)	11.72	13.296	11.236	9.522
	(1.280)	(1.750)	(2.056)	(1.198)
Number of seeds/head	542.792	541.244	507.566	479.973
	(103.289)	(135.092)	(101.079)	(91.001)
Weight of seeds/plant (g)	31.214	29.878	27.310	25.149
	(7.549)	(7.181)	(6.212)	(6.045)
Weight of 1000 seeds (g)	57.622	55.674	53.569	51.956
	(7.982)	(9.629)	(6.896)	(6.769)
Seed output/hectare (tonnes)	2.601	2.490	2.276	2.096
	(0.629)	(0.599)	(0.518)	(0.504)
Seed oil content (%)	47.847	47.370	47.553	47.350
	(1.274)	(1.846)	(3.504)	(1.613)
Oil output/hectare (tonnes)	1.211	1.133	1.034	0.955
	(0.313)	(0.247)	(0.300)	(0.225)
Harvest index	0.227	0.226	0.239	0.249
	(0.039)	(0.032)	(0.045)	(0.031)

Figures in the parenthesis indicate the standard deviation.

T_1= Treatment 1 = Farm Yard Manure (FYM) +Mineral Fertilizers (NPK)
T_2= Treatment 2 = Mineral Fertilizers (NPK)
T_3= Treatment 3 = Farm Yard Manure (FYM)
T_4= Treatment 4 = Control.

TABLE 3 B 1 : SUNFLOWER - FUNCTIONAL BEHAVIOUR

SEASON : WINTER

PARAMETERS	TREATMENTS			
	T_1	T_2	T_3	T_4
Head diameter (cm)	17.460	16.550	15.665	13.333
	(1.353)	(1.729)	(1.442)	(1.648)
Number of seeds/head	639.00	525.333	436.333	351.333
	(123.760)	(92.234)	(30.578)	(43.903)
Weight of seeds/plant (g)	35.780	27.070	22.950	17.090
	(8.839)	(8.044)	(3.921)	(9.003)
Weight of 1000 seeds (g)	55.6	50.621	52.965	48.498
	(4.478)	(6.496)	(11.225)	(4.385)
Seed output/hectare (tonnes)	2.988	2.256	1.912	1.424
	(0.744)	(0.670)	(0.327)	(0.250)
Seed oil content (%)	44.290	43.383	44.566	43.091
	(1.680)	(1.922)	(2.207)	(3.463)
Oil output/hectare (tonnes)	1.247	0.930	0.803	0.576
	(0.327)	(0.283)	(0.149)	(0.119)
Harvest index	0.234	0.195	0.189	0.183
	(0.046)	(0.057)	(0.021)	(0.038)

Figures in the parenthesis indicate the standard deviation.

T_1= Treatment1= Farm Yard Manure (FYM) + Mineral Fertilizers (NPK)

T_2= Treatment 2 = Mineral Fertilizers (NPK)

T_3= Treatment 3 = Farm Yard Manure (FYM)

T_4= Treatment 4 = Control.

TABLE 4 B 1 - SUNFLOWER - FUNCTIONAL BEHAVIOUR

SEASON : SUMMER

PARAMETERS	TREATMENTS			
	T_1	T_2	T_3	T_4
Head diameter (cm)	17.070	17.478	15.098	14.500
	(0.719)	(1.226)	(2.279)	(2.168)
Number of seeds/head	541.690	542.783	513.752	459.378
	(107.897)	(101.776)	(117.450)	(149.082)
Weight of seeds/plant (g)	28.397	26.962	26.263	21.225
	(5.609)	(6.009)	(5.790)	(6.399)
Weight of 1000 seeds (g)	52.757	49.666	51.252	46.827
	(6.220)	(6.273)	(2.355)	(4.159)
Seed output/hectare (tonnes)	2.367	2.246	2.188	1.769
	(0.467)	(0.500)	(0.483)	(0.284)
Seed oil content (%)	38.880	38.250	38.490	35.230
	(0.964)	(1.164)	(1.320)	(0.998)
Oil output/hectare (tonnes)	0.891	0.830	0.801	0.565
	(0.187)	(0.185)	(0.207)	(0.181)
Harvest index	0.163	0.163	0.197	0.171
	(0.026)	(0.031)	(0.025)	(0.046)

Figures in the parenthesis indicate the standard deviation.

T_1 = Treatment 1 = Farm Yard Manure (FYM) + Mineral Fertilizers (NPK)
T_2 = Treatment 2 = Mineral Fertilizers (NPK)
T_3 = Treatment 3 = Farm Yard Manure (FYM)
T_4 = Treatment 4 = Control.

per head was observed in this aspect also (Tables 2 B1, 3 B1, and 4 B1; Fig. 4).

Test Weight of Seeds (weight of 1000 seeds) (g) :

In general the fertilizer treatments, in all seasons gave higher test weight of seeds (Tables 2 B1, 3 B1, and 4 B1; Fig. 3). Treatment-1 (NPK + FYM) among others resulted in a significant increase in the test weight of seeds as compared to that of control.

Seed output (tonnes/ha) :

The application of fertilizer resulted in an increased seed production on an area basis; in all seasons (Tables 2 B1, 3 B1, and 4 B1; Fig. 3). Treatment-1 (NPK + FYM) gave rise to a higher yield of seed as compared to the seed output in control.

Seed Oil Content (%) :

All treatments brought about an increase in the oil content of seed (%) (Tables 2 B1, 3 B1, and 4 B1; Fig. 3). Among the different seasons monsoon has been found to be significantly better for higher seed oil content (%) followed by winter.

Harvest Index :

Among different seasons highest values for this parameter

were obtained in monsoon (Tables 2B1, 3B1 and 4 B1; Fig. 3).In monsoon application of fertilizers did not increase this value. However, in winter the application of fertilizers resulted in an increase in this value. Among different treatments T_1 (NPK + FYM) gave the highest value. In summer, treatment of plants with FYM only gave a higher value as compared to that of other treatments and control.

Oil Yield (tonnes/ha) :

As in the case of seed oil content, all fertilizer treatments were found to favour the production of oil on an area basis (Tables 2 B1, 3 B1, and 4 B1; Fig. 3). Among the different treatments, the Treatment$_1$ (NPK + FYM) in all seasons gave a significantly higher yield of oil per hectare. The yield of oil in monsoon was highest. The yield of oil was the lowest in summer.

Growth Analysis :

In monsoon the Net Primary Productivity (NPP) during the initial stage was low and it showed a steady increase registering a peak on the 60th day (Table 2 C; Fig. 6A). NPP declined after 60th day and reached a lower level than that of the initial stage by the final harvest. The plants which received the combined dose of NPK and FYM showed a higher NPP on 75th day also as compared to that under other treatments.

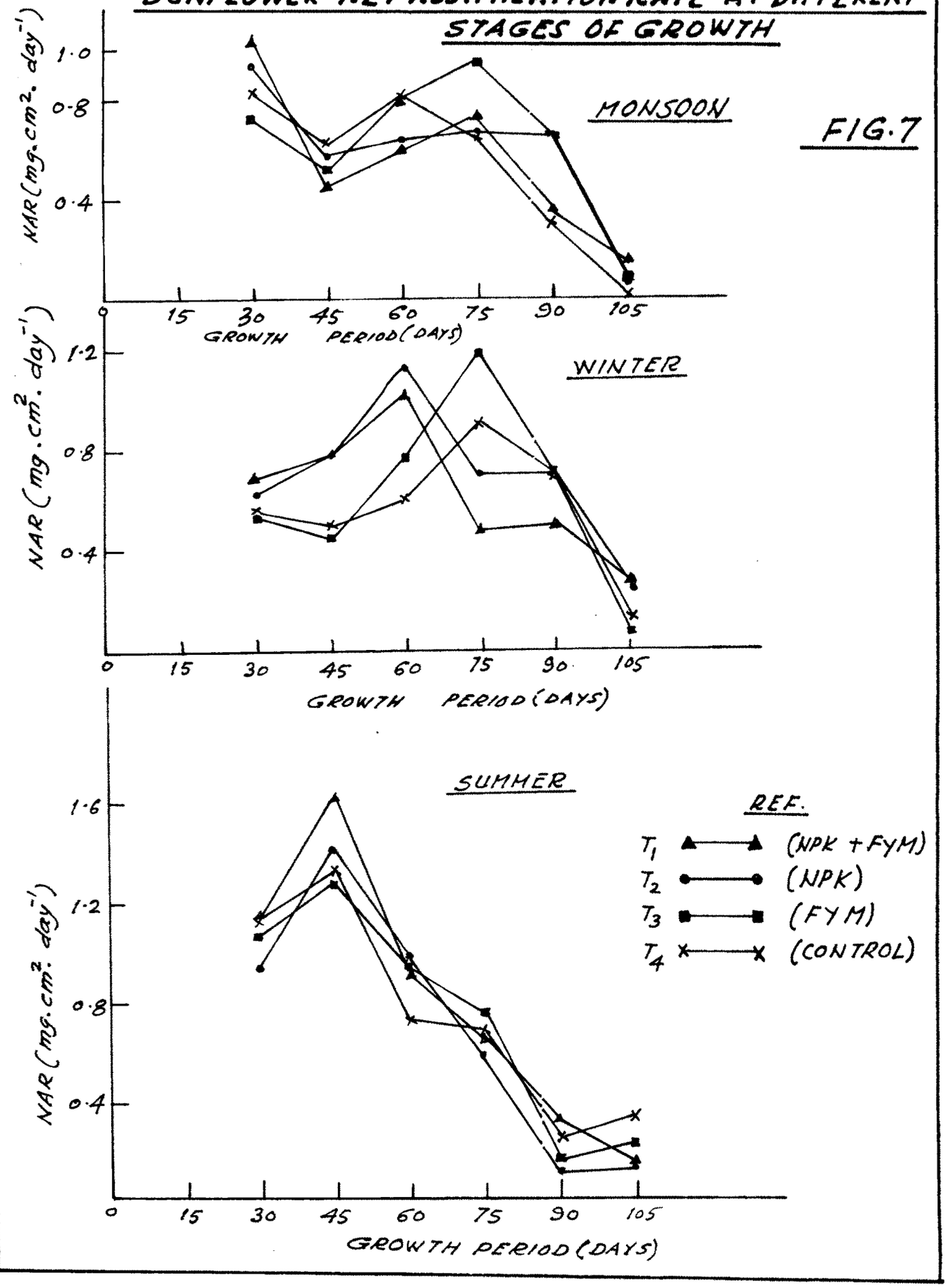
The pattern of productivity of winter grown plants also exhibited the same trend as observed in monsoon (Tables 3 C and 4 C). While plants under Treatment-1 (NPK + FYM) and Treatment-2 (NPK) showed the peak of NPP during 60th day as in monsoon, those under Treatment-3 (FYM) and Treatment-4 (Control) attained the peak of NPP during 75th day. In general the winter grown plants showed a higher rate of production as compared to those in monsoon. In winter also Treatment-1 (NPK + FYM) exhibited the maximum NPP. The NPP of plants under Treatment-3 (FYM) though attained a delayed peak showed a higher rate of production as compared to that of Treatment-2 (NPK). During summer also the pattern of productivity followed the same trend as that in monsoon. In general the net production during summer was higher as compared to that of winter and monsoon. Plants under Treatment-1 (NPK + FYM) and Treatment-2 (NPK) showed the same level of NPP while those under Treatment-3 (FYM) showed a lower and Treatment-4 (Control) showed the lowest levels of NPP.

Net Assimilation Rate (NAR) $mg.cm^2.\ day^{-1}$:

During monsoon the NAR declined to a relatively low level on 45th day compared to the 30th day (Table 2 C; Fig. 7). Thereafter it showed a slight increase during 60th day and registered a peak on 75th day (except in the control) and declined thereafter. In the case of Treatment-4 (Control)

SUNFLOWER-NET ASSIMILATION RATE AT DIFFERENT STAGES OF GROWTH

FIG.7



the second rise in NAR was observed on 60th day after an initial fall and then it fell sharply. In winter the NAR of plants at the initial stage (30th day) was lower than in monsoon (Tables 3C and 4 C; Fig. 7). The NAR of plants under Treatment-1 (NPK+FYM) and Treatment-2 (NPK) showed a steady increase during 45th day and registered the peak on 60th day. It declined sharply to a low level by 75th day and it almost remained steady between 75th and 90th days before it finally declined. In the case of Treatment-3 (FYM) and Treatment-4 (Control) NAR showed a slight reduction by 45th day and then increased steadily registering the peak on 75th day and declined thereafter. Among different treatments the highest NAR was observed in the case of plants treated with FYM (T-3). The NAR during initial stage in summer was higher as compared to that in monsoon and winter. In all treatments it increased steadily and reached the peak on 45th day before it declined to a lowest level by the final harvest time. Among the different treatments, Treatment-1 (NPK + FYM) showed the highest NAR.

Relative Growth Rate (RGR) : $g.g^{-1}.\ day^{-1}$

In monsoon the RGR was highest uniformly under all the treatments during the initial period, of growth and it declined steadily as the growth advanced (Table 2 C; Fig. 8). In winter the RGR of plants under treatments 3 and 4 (FYM and Control respectively) on 75th day showed a slightly higher

level as compared to that of plants under the other two treatments (Table 3 C; Fig. 8). RGR in summer maintained the same trend as that in monsoon (Table 4 C; Fig. 8).

Leaf Area Index (LAI) : $\underset{LA}{cm^2}/\underset{GA}{cm^2}$

The leaf area index of plants under all treatments in all the seasons exhibited the same trend as that of NPP (Tables 2 C, 3 C and 4 C; Fig. 6 B).

Leaf Area Ratio (LAR) : $cm^2 . g^{-1}$

The LAR (Tables 2 C, 3 C and 4 C; Fig. 5 A) showed similar trend as that of RGR. The same trend with a slight deviation was observed in winter. The LAR of plants under Treatments 3 and 4 (FYM and Control respectively) showed a slight increase on 30th day before it started declining as in other treatments. The pattern of LAR in summer was also similar to that observed in monsoon.

NIGER

Morphological behaviour

The growth phase of niger in monsoon was much prolonged (120 days) compared to the same in the other two seasons (105 days).

1. The Length of Root :

In all seasons and under all treatments the maximum rate of elongation of the root was observed between 15th and 30th day (Tables 5 A, 6 A and 7 A). In summer and winter the growth was rapid till 60th day, while in monsoon it was so upto 75th day. The growth rate of roots, progressively decreased thereafter. Maximum growth of roots was observed in summer and minimum in winter. Among different treatments the growth of root was most favoured by Treatment-3 (FYM) during summer and winter, whereas in monsoon it was favoured by Treatment-1 (NPK + FYM).

2. The Length of Stem :

As in the case of roots, the maximum rate of elongation was found between 15th and 30th day (Tables 5 A, 6 A and 7 A). Rapid growth of stem was observed till 60th day in all seasons under all treatments. Among different seasons maximum growth of stem was observed in monsoon. Though all treatments promoted the growth of stem in all seasons over the control the maximum height was observed under Treatment-3 (FYM).

3. The root/shoot length ratio :

In all seasons under all treatments the highest value of root/shoot ratio was observed. on the 15th day when the initial observation was made (Tables 5 A, 6 A and 7 A). This

ratio showed a steady decrease as time progressed. In the control, however, a trend towards a slight increase in the ratio was observed from 75th day onwards. In all seasons the highest ratio on the 15th day was under Treatment-3 (FYM). But at the time of final harvest the root/shoot ratio was highest under Treatment-1 (NPK + FYM) in winter and monsoon, whereas in summer the highest ratio was observed in the control (Treatment-4).

4. Number of green leaves per plant :

The largest number of leaves per plant was observed on 60th day during winter and monsoon, while in summer the same was observed on 45th day (Tables 5 A, 6 A and 7 A). Among different treatments, the maximum number of leaves was observed in plants under Treatment-1 (NPK + FYM) during summer and monsoon, while in winter the maximum number of leaves was observed under treatment-3 (FYM).

5. Average Area per leaf (cm^2) :

The average area per leaf increased with age and the highest values were observed on 45th day during all seasons (Tables 5 A, 6 A and 7 A). In summer and monsoon the NPK treated plants (Treatment-2) showed maximum area per leaf on 15th day, whereas in winter the plants under Treatment-1 (NPK + FYM) showed the maximum area per leaf. Same trend was also observed on 45th day.

6. Total leaf area per plant :

Total leaf area per plant on 15th day was highest under Treatment-2 (NPK) in monsoon and summer while in winter the highest value was observed under T-1 (NPK + FYM) (Tables 6 A, and 7 A; Fig. 14 B). In all treatments the leaf area per plant showed a steady increase and registered the peak on 45th day in monsoon and summer; during winter the peak was observed on 60th day and declined thereafter. The maximum leaf area per plant was observed under Treatment-1 (NPK + FYM) in monsoon and summer, while in winter it was observed under Treatment-3 (FYM). Among different seasons the maximum total leaf area per plant was observed in monsoon in general.

Functional behaviour

Total Biomass : ($g \cdot plant^{-1}$)

The dry matter production (biomass) showed a steady increase till 60th day and thereafter it slowed down (Tables 5 B, 6 B and 7 B; Fig. 9 A). The total dry matter production was maximum during monsoon and the minimum during winter. During all seasons, among different treatments, treatment-1 (NPK + FYM) gave the maximum production of dry matter followed by Treatment-3 (FYM).

Root/Shoot weight ratio :

As it can be seen from Tables 5 B, 6 B and 7 B the ratio

showed an increase on 30th day and it declined gradually till the final harvest. The treatments did not show any marked difference in their effect on this ratio. However, during winter Treatment-2 (NPK) showed a higher value. Among different seasons the highest values were observed in monsoon.

Chlorophyll Content ($mg \cdot g^{-1}$ fresh weight of green leaves) :

No regular pattern is observable in this parameter. In all seasons and under all treatments in general the chlorophyll content gradually decreased from 60th day onwards till the final harvest.

Number of heads per plant :

The maximum number of heads per plant was found during monsoon, and the minimum in winter (Tables 5 B1,6 B1, 7 B1; Fig. 10). Among the different treatments, Treatment-1 (NPK + FYM) and Treatment-3 (FYM) gave higher number of heads as compared to T-2 (NPK) and T-4 (Control). This was true in all the three seasons.

Number of seeds per head :

Winter grown plants produced larger number of seeds per head as compared to those of monsoon and summer (Tables 5 B, 6 B, 7B; Fig. 10). Among different treatments T-1 (NPK + FYM) gave the largest number of seeds per head.

TABLE 5 B 1 : NIGER - FUNCTIONAL BEHAVIOUR

SEASON : MONSOON

PARAMETERS	TREATMENTS			
	T_1	T_2	T_3	T_4
Number of heads/plant	68.500	59.668	68.550	44.666
	(7.503)	(5.255	(11.053)	(12.638)
Number of seeds per head	12.413	9.94	11.269	10.635
	(1.879)	(1.685)	(1.536)	(0.994)
Number of seeds/plant	851.477	587.174	775.737	468.381
	(185.624)	(73.317)	(103.703)	(106.590)
Weight of seeds/plant (g)	3.711	2.425	3.206	1.864
	(1.156)	(0.367)	(0.307)	(0.474)
Weight of 1000 seeds (g)	4.292	4.122	4.188	3.965
	(0.389)	(0.241)	(0.440)	(0.320)
Seed output/hectare (kg)	309.249	202.083	267.166	155.333
	(96.331)	(30.584)	(23.388)	(36.098)
Seed oil content (%)	39.542	37.947	39.929	38.397
	(2.411)	(3.933)	(2.816)	(2.183)
Harvest index	0.107	0.078	0.094	0.088
	(0.035)	(0.010)	(0.011)	(0.025)
Oil output/hectare (kg)	119.502	74.878	105.573	58.307
	(11.711)	(13.181)	(13.936)	(16.970)

Figures in the parenthesis indicate the standard deviation.

T_1 = Treatment 1 = Farm Yard Manure (FYM) + Mineral fertilizers(NPK

T_2 = Treatment 2 = Mineral fertilizers (NPK)

T_3 = Treatment 3 = Farm Yard Manure (FYM)

T_4 = Treatment 4 = Control.

TABLE 6 B 1 : NIGER - FUNCTIONAL BEHAVIOUR

SEASON : WINTER

PARAMETERS	TREATMENTS			
	T_1	T_2	T_3	T_4
Number of heads/plant	21.640	20.360	21.00	18.665
	(2.455)	(1.800)	(1.671)	(2.588)
Number of seeds/head	15.5	14.21	14.633	13.555
	(3.782)	(1.252)	(1.750)	(2.700)
Number of seeds/plant	332.838	289.430	308.547	255.705
	(77.182)	(37.103)	(53.870)	(70.486)
Weight of seeds/plant (g)	1.531	1.242	1.311	0.939
	(0.461)	(0.266)	(0.284)	(0.272)
Weight of 1000 seeds (g)	4.555	4.259	4.245	3.661
	(0.725)	(0.491)	(0.377)	(0.191)
Seed output/hectare (kg)	127.549	103.490	109.277	78.415
	(38.44)	(22.140)	(23.64)	(22.661)
Seed oil Content (%)	45.222	40.914	43.666	38.550
	(5.022)	(4.938)	(2.225)	(3.915)
Harvest index	0.304	0.315	0.279	0.281
	(0.089)	(0.069)	(0.055)	(0.079)
Oil output/hectare (kg)	55.045	39.303	45.163	27.864
	(20.364)	(9.643)	(10.287)	(8.437)

Figures in the parenthesis indicate the standard deviation.

T_1 = Treatment 1 = Farm Yard Manure (FYM) + Mineral Fertilizers (NPK)

T_2 = Treatment 2 = Mineral Fertilizers (NPK)

T_3 = Treatment 3 = Farm Yard Manure (FYM)

T_4 = Treatment 4 = Control.

TABLE 7 B 1 : NIGER - FUNCTIONAL BEHAVIOUR

SEASON : SUMMER

PARAMETERS	TREATMENTS			
	T_1	T_2	T_3	T_4
Number of heads/plant	57.876	48.693	53.166	36.333
	(8.284)	(15.026)	(13.136)	(10.053)
Number of seeds/head	12.00	11.75	12.025	9.990
	(2.990)	(1.940)	(1.475)	(1.735)
Number of seeds/plant	687.313	589.731	624.067	362.608
	(164.803)	(245.249)	(82.53)	(116.542)
Weight of seeds/plant (g)	2.974	2.428	2.510	1.284
	(1.101)	(0.908)	(0.503)	(0.388)
Weight of 1000 seeds (g)	4.209	4.157	4.00	3.562
	(0.66)	(0.382)	(0.353)	(0.173)
Seed output/hectare (kg)	247.809	201.735	209.179	106.957
	(91.769)	(75.717)	(41.909)	(32.292)
Seed oil content (%)	40.55	39.005	39.575	38.005
	(2.916)	(5.928)	(2.639)	(2.962)
Harvest index	0.115	0.138	0.131	0.105
	(0.035)	(0.057)	(0.029)	(0.033)
Oil output/hectare (kg)	97.738	58.321	80.985	39.638
	(40.611)	(12.915)	(11.295)	(13.246)

Figures in the parenthesis indicate the standard deviation.

T_1= Treatment1= Farm Yard Manure (FYM) + Mineral Fertilizers (NPK)

T_2= Treatment 2 = Mineral Fertilizers (NPK)

T_3= Treatment 3 = Farm Yard Manure (FYM)

T_4= Treatment 4 = Control.

Number of seeds per plant :

The yield of number of seeds per plant exhibited the same trend as that of number of heads per plant (Tables 5 B1, 6 B1, and 7 B1; Fig. 10).

Weight of seeds per plant :

Treatment-1 (NPK + FYM), in all seasons gave the highest yield of seed per plant, closely followed by T-3 (FYM) (Tables 5 B1, 6 B1, and 7 B1; Fig. 10). However, T-2 (NPK) gave better yield than T-4 (Control). With respect to seasons, the best yields were obtained in monsoon.

Weight of one thousand seeds :

The weight of 1000 seeds did not vary much between treatments or between seasons (Tables 5 B1, 6 B1, 7 B1; Fig. 10). However, in control in all seasons the c test weight of seeds was slightly lower than in treatment-3. Though not significantly higher values were obtained under treatment-1.

Seed output : kg/ha

The monsoon and summer yields are significantly higher

than the winter yields (Tables 5 B1, 6 B1, 7 B1; Fig. 11). All the treatments yield significantly higher than the control, but in winter and summer there is no appreciable difference in yields under treatment 2 (NPK) and treatment 3 (FYM).

Seed Oil Content (%) :(Tables 5 B 1, 6 B1, and 7 B1; Fig. 11)

Seed oil content(%)is fairly uniform in all seasons and under all treatments especially during summer. In monsoon and winter T-1 (NPK + FYM) and T-3 (FYM) give consistently higher oil % than T-2 (NPK) or the Control (T-4).

Harvest Index : (Tables 5 B1, 6 B1, and 7 B1; Fig. 11)

Among different seasons the highest values for the parameter were obtained in winter and the lowest in monsoon (Table 9; Fig. 11). In monsoon T-1 (NPK + FYM) and T-3 (FYM) gave slightly higher values over the control. Among different treatments T-1 (NPK + FYM) gave the highest value. In winter T-1 (NPK + FYM) and T-2 (NPK) gave higher values as compared to T-3.(FYM) and control. The highest value was obtained under the influence of T-2 (NPK). In summer all the three treatments gave higher values as compared to that of control. Among different treatments T-2 (NPK) and T-3 (FYM) gave almost identical values.

Oil Yield (Kg/hectare) :

As one would expect from the relatively uniform oil

content under all conditions, the oil yield (kg/hectare) shows a pattern similar to that of seed output/hectare (Tables 5 B1, 6 B1 and 7 B1; Fig. 11).

Growth Analysis :

Net Primary Productivity (NPP) : $g.plant^{-1}.day^{-1}$

The rate of primary production was low during the initial stage and it increased steadily and reached the maximum on 60th day and declined thereafter (Tables 5 C, 6 C and 7 C; Fig. 12 A). Among different seasons maximum NPP was observed in plants under T-1 (NPK + FYM) followed by T-3 (FYM) and T-2 (NPK). In summer the NPP under T-1 was conspicuously higher than other treatments and the control.

Net Assimilation Rate : (NAR) $mg.cm^{2}.\ day^{-1}$

Among different seasons the highest NAR was observed during summer (Tables 5 C, 6 C and 7 C; Fig. 13 A). In monsoon NAR was high on 30th, 75th and 105th days (except in plants under T-1 (NPK + FYM)). During monsoon, among different treatments T-3 (FYM) showed the highest rate.

During winter the NAR was high on 45th and 75th days, irrespective of treatments. Under Treatment-1 (NPK + FYM) the NAR was highest on 45th day. However, in plants under Treatment-2 (NPK), Treatment-3 (FYM) and Treatment-4 (Control) the highest rate was observed on 75th day.

Plants in summer initially showed a high NAR which declined on 45th day and it increased thereafter, registering the peak on 60th day. The NAR steadily decreased after 60th day. Among different treatments the NAR was the highest in plants under Treatment-1 (NPK + FYM).

Relative Growth Rate (RGR) : ($g.g^{-1}$. day^{-1})

The relative growth rate was maximum on 30th day and it showed a steady decrease, as the age advanced and reached a very low value in the final state (Tables 5 C, 6 C and 7 C; Fig. 14 A). Among different seasons highest RGR was observed in summer on 30th day. Among different treatments T-1 (NPK + FYM) exhibited highest RGR during monsoon and winter, whereas in summer T-3 (FYM) showed the highest RGR.

Leaf Area Index (LAI) cm^2 LA/cm^2 GA

The Leaf Area Index showed a steady increase on 15th day onwards and registered the maximun value on 45th day during summer and monsoon and on 60th day in winter (Tables 5 C, 6 C and 7 C; Fig. 13 B), thereafter it declined. Among different seasons the highest LAI was observed during monsoon. Among different treatments T-1 (NPK + FYM) gave the highest value in all seasons. However, there was no marked difference between T-1 (NPK + FYM) and T-3 (FYM).

Leaf Area Ratio (LAR) $cm^2 . g^{-1}$

Leaf Area Ratio (Tables 5 C, 6 C and 7 C; Fig. 12 A) also exhibited a trend similar to that of RGR. In monsoon and summer Treatment-2 (NPK) showed the highest LAR. But in winter highest LAR was observed in Control. However, among different treatments Treatment-1 (NPK + FYM) gave the highest ratio as compared to that under Treatment-2 (NPK) and Treatment-3 (FYM). Among different seasons highest LAR was observed in monsoon.

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