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Study of soybean genotypes to examine the dynamics of dry matter accumulation during the seed filling period

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Abstract
The experiment was conducted at the experimental site of Botany Department, Vasantrao Naik Marathwada Agricultural University (VNMKV), Parbhani during the period from June to October 2017 to evaluate seven selected soybean genotypes in respect of growth, dry matter production and yield. Genotypic variations in plant height, leaf area, leaf area index, leaf area duration, dry matter and seed yield were observed. The leaf area ranged from 1296.70 to 1421 (cm^2) at 45 DAS and 1416.7 to 1538 (cm^2) at 60 DAS, leaf area index varied from 5.57 to 6.30 at 45 DAS and 6.12 to 6.74 at 60 DAS, total dry matter ranged from 17.11 to 18.28 g per plant at 65 DAS and 31.28 to 34.30 at 85 DAS. The seed yield ranged from 717.54 to 1125.00 kg per hectare. Seed yield of soybean was positively related to total dry matter. The filled pods per plant had good relationship with seed yield than other components.

Keywords: Soybean, growth, seed yield, dry matter

Introduction
Soybean (*Glycine max* (L.) Merrill] one of nature's most versatile crops, is increasingly becoming an important food and cash crop in the tropics due to its high nutrient quality and adaptability to various growing environments (M. C. Kevit, 2005) [11].
It is the most important *kharif* oilseed crop of Maharashtra. Area under soybean during 2017-18 was 101.56 lakh ha with production of 83.50 lakh MT besides productivity of 822 kg per ha in India. While in Maharashtra area under soybean was 34.84 lakh ha with production of 29 lakh MT besides productivity of 841 kg per ha. (SOPA 2017-18).
Being a rich source of protein and oil, it is also referred to as vegetarian meat and can substitute egg, meat or cod-liver oil. The soybean is widely used in the preparation of various food products which ranged from milk to biscuits, cakes, sweets and other confectionery production. The soya milk prepared form soybean is equally nutritious as that of cow and sheep and oil cakes are very nourishing feed for the livestock and poultry. Soybean oil is used for manufacturing vanaspati ghee and several other industrial products. It is widely used in the industrial production of different antibiotics. Soybean, being the richest, cheapest and easiest source of the best multiplicity of uses as food and industrial products the future demand for soybean will increase and the soybean yield must be improved to meet this demand and hence called a "wonder crop".

Material and Methods
The present investigation on "Study of Soybean genotypes to examine the dynamics of dry matter accumulation during the seed filling period." was conducted at experimental farm of Dept. of Agril. Botany, VNMKV, Parbhani during *kharif* 2017. The experiment material for the present investigation consisted of seven genotypes. These selected seven genotypes possess good amount of variation for number of branches, number of nodes, days to 50% flower, leaf area, leaf area index, leaf area duration, number of pods per plant, developing seed weight, weight of pod wall, length of pod, diameter of pod, number of seed per pod, number of pods per plant, harvest index, biomass along with seed yield per plant. The seven genotypes used in the present study were MAUS-158, MAUS-162, MAUS-81, MAUS-71, MAUS-612, JS-335 and JS-93-05. The experiment was laid in randomized block design with three replications. Each genotype was randomized in each block and sown in rows of 5m length at 45x15 cm spacing.

Result and Discussion

a) Number of branches per plant

In the present study the number of branches per plant ranged from 3.64 to 5.56. Genotype G2 (5.56) had significantly higher number of nodes per plant over remaining genotypes except G7 (5.17) which was at par. However, genotype G3 (3.64) noted minimum branches/plant.

These results are consistent with the study of Adasul D.L., (2013) [2], Devendra Vasht., (2016) [7] showed that the genotype G5 (4.66) had significantly higher number of branches over remaining genotypes.

b) Number of nodes per plant

In the present study the number of branches per plant ranged from 10.92 to 13.98. Genotype G2 (13.98) had significantly higher number of branches over remaining genotypes except G7 (13.76), G1 (12.77) and G4 (12.07) which were at par with each other. However, genotype G3 (10.92) recorded minimum nodes per plant.

A study was conducted on 170 soybean genotypes under Soil salinity in nine morpho-physiological characters on 30-days-old seedlings plants. Baraskar *et al*. (2014) [5]. The perusal of the data revealed that higher PCV and GCV were recorded for number of clusters per plant.

Table 1: Plant height in Soybean genotypes

Genotype		Plant height (cm)
G1	MAUS-162	72.05
G2	MAUS-158	65.29
G3	JS-93-05	60.33
G4	MAUS-612	67.28
G5	JS-335	58.55
G6	MAUS-81	64.13
G7	MAUS-71	70.10
	G.M.	65.39
	S.E±	1.74
	C.D. at 5%	5.76
	C.V. (%)	4.61

Table 2: Number of branches per plant in Soybean genotypes.

	Genotype	No. of branches per plant
G1	MAUS-162	4.21
G2	MAUS-158	5.56
G3	JS-93-05	3.64
G4	MAUS-612	4.37
G5	JS-335	3.97
G6	MAUS-81	4.00
G7	MAUS-71	5.17
	G.M.	4.42
	S.E±	0.38
	C.D. at 5%	1.19
	C.V. (%)	15.12

Table 3: Number of nodes per plant in Soybean genotypes.

Genotype		No. of nodes per plant
G1	MAUS-162	12.77
G2	MAUS-158	13.98
G3	JS-93-05	10.92
G4	MAUS-612	12.07
G5	JS-335	11.32
G6	MAUS-81	11.56
G7	MAUS-71	13.76
	G.M.	12.34
	S.E±	0.68
	C.D. at 5%	2.08
	C.V. (%)	9.49

Table 4: Number of nodes per plant in Soybean genotypes.

Genotype		No. of nodes per plant
G1	MAUS-162	12.77
G2	MAUS-158	13.98
G3	JS-93-05	10.92
G4	MAUS-612	12.07
G5	JS-335	11.32
G6	MAUS-81	11.56
G7	MAUS-71	13.76
	G.M.	12.34
	S.E±	0.68
	C.D. at 5%	2.08
	C.V. (%)	9.49

c) Pod length (cm)

The Present study showed that the length of pod of soybean genotype recorded at different crop growth stages are presented in Table 5. The results revealed length of pod was non significant (at 5%) among various genotypes at 65 DAS, 75 DAS and significant for 85 DAS as shown in (Table 7).

The results are in confirmatory with Adasul D.L., (2013) [2], Devendra Vasht., (2016) [4], Barskar *et al*., (2014) [5], Ratan Bahale (2012) [4], Mane A.M., (2013) [10]. The data indicated that JS 93-05 (45.23), JS 20-40 (38.61) possessed the significantly higher pod length than other genotypes. JS97-52 (28.69) showed the minimum value for this attribute.

Table 5: Dry matter (gm/plant) in Soybean genotypes

Genotype		Dry matter gm/plant		
		65 DAS	75 DAS	85 DAS
G1	MAUS-162	17.95	28.04	32.65
G2	MAUS-158	18.28	34.34	34.3
G3	JS-93-05	18.06	33.12	33.20
G4	MAUS-612	17.70	32.12	34.08
G5	JS-335	17.11	31.81	33.14
G6	MAUS-81	18.07	28.32	31.28
G7	MAUS-71	18.24	28.33	34.28
	G.M.	17.92	30.87	33.27
	S.E. ±	1.28	1.17	1.02
	C.D. at 5%	1.32	1.04	0.91
	C.V. (%)	1.84	1.90	1.54

Table 6: SCMR value in Soybean genotype at flowering stage

	Genotype	SCMR Value
G1	MAUS-162	46.32
G2	MAUS-158	44.79
G3	JS-93-05	41.47
G4	MAUS-612	44.36
G5	JS-335	45.60
G6	MAUS-81	43.13
G7	MAUS-71	41.54
	G.M.	43.89
	S.E±	0.75
	C.D. at 5%	2.29
	C.V. (%)	2.94

Table 7: Relative water content in Soybean genotypes

Genotype		Relative water content (%)		
		Vegetative stage	Grain filling stage	Physiological maturity stage
G1	MAUS-162	65.13	47.30	40.80
G2	MAUS-158	70.43	51.76	45.77
G3	JS-93-05	60.76	43.77	38.77
G4	MAUS-612	65.50	48.83	44.17
G5	JS-335	60.36	42.69	36.03
G6	MAUS-81	68.26	49.92	44.26
G7	MAUS-71	69.41	52.73	44.74
	G.M.	65.98	48.14	42.07
	S.E±	1.36	0.95	1.86
	C.D. at 5%	4.21	2.94	5.75
	C.V. (%)	3.61	3.43	7.69

d) Diameter of pod (cm)

The Present study showed that the diameter of pod of soybean genotype recorded at different crop growth stages are presented in Table 8. The results revealed diameter of pod was non significant (at 5%) among various genotypes at 65 DAS, 75 DAS and significant for 85 DAS as shown in (Table 8).

The results are in confirmatory with Ratan Bahale., (2012) [4]. Significantly higher pod diameter was recorded in genotype JS 97-52 (4.55) at par with JS 20-36 (4.45).

Table 8: Pod length in Soybean genotype at different growth stages.

Genotype		Length of pod (cm)		
		65 DAS	75 DAS	85 DAS
G1	MAUS-162	1.25	2.43	3.69
G2	MAUS-158	1.39	2.60	3.91
G3	JS-93-05	1.37	2.58	3.76
G4	MAUS-612	1.33	2.52	3.65
G5	JS-335	1.26	2.43	3.52
G6	MAUS-81	1.30	2.48	3.58
G7	MAUS-71	1.27	2.44	3.62
	G.M.	1.31	2.49	3.68
	S.E. ±	0.04	0.05	0.09
	C.D. at 5%	NS	NS	0.74
	C.V.	5.79	3.65	4.57

Table 9: Pod diameter in Soybean genotype at different growth stages

Genotype		Diameter of pod (cm)		
		65 DAS	75 DAS	85 DAS
G1	MAUS-162	0.37	0.67	0.83
G2	MAUS-158	0.35	0.54	0.67
G3	JS-93-05	0.37	0.62	0.69
G4	MAUS-612	0.37	0.63	0.82
G5	JS-335	0.42	0.66	0.81
G6	MAUS-81	0.39	0.69	0.76
G7	MAUS-71	0.39	0.61	0.75
	G.M.	0.38	0.63	0.76
	S.E. ±	0.03	0.04	0.03
	C.D. at 5%	NS	NS	0.09
	C.V. (%)	12.76	10.24	6.50

Table 10: Developing seed weight in Soybean genotype at different growth stages

Genotype		Developing seed weight (gm)/pod		
		65 DAS	75 DAS	85 DAS
G1	MAUS-162	0.13	0.23	0.50
G2	MAUS-158	0.18	0.26	0.72
G3	JS-93-05	0.13	0.23	0.55
G4	MAUS-612	0.14	0.25	0.52
G5	JS-335	0.15	0.23	0.60
G6	MAUS-81	0.10	0.22	0.58
G7	MAUS-71	0.16	0.25	0.65
	G.M.	0.14	0.24	0.59
	S.E. ±	0.02	0.02	0.04
	C.D. at 5%	NS	NS	0.11
	C.V. (%)	20.71	11.25	10.33

Table 11: Weight pod wall in Soybean genotype at different growth stages

Genotype		Weight of pod wall (gm)		
		65 DAS	75 DAS	85 DAS
G1	MAUS-162	0.10	0.12	0.15
G2	MAUS-158	0.13	0.15	0.17
G3	JS-93-05	0.08	0.11	0.13
G4	MAUS-612	0.11	0.13	0.15
G5	JS-335	0.12	0.14	0.14
G6	MAUS-81	0.07	0.10	0.11
G7	MAUS-71	0.10	0.13	0.12
	G.M.	0.10	0.12	0.14
	S.E. ±	0.006	0.01	0.001
	C.D. at 5%	0.019	NS	0.03
	C.V. (%)	10.50	17.58	12.11

Table 12: Number of pods per plant in Soybean genotypes

Genotypes		No. of pods per plant
G1	MAUS-162	83.31
G2	MAUS-158	92.36
G3	JS-93-05	78.68
G4	MAUS-612	82.28
G5	JS-335	74.47
G6	MAUS-81	76.24
G7	MAUS-71	87.89
	G.M.	82.18
	S.E±	1.41
	C.D. at 5%	4.36
	C.V. (%)	2.98

Table 13: Number of seeds per pod in Soybean genotypes.

Genotype		No. of seeds per pod
G1	MAUS-162	2.86
G2	MAUS-158	2.93
G3	JS-93-05	3.46
G4	MAUS-612	2.92
G5	JS-335	2.80
G6	MAUS-81	2.53
G7	MAUS-71	2.63
	G.M.	2.88
	S.E±	0.20
	C.D. at 5%	0.84
	C.V. (%)	8.41

Table 14: Number of pods per node in Soybean genotypes.

Genotype		No. of pods per node
G1	MAUS-162	5.74
G2	MAUS-158	6.08
G3	JS-93-05	4.26
G4	MAUS-612	4.69
G5	JS-335	3.97
G6	MAUS-81	4.03
G7	MAUS-71	5.34
	G.M.	4.87
	S.E±	0.37
	C.D. at 5%	1.13
	C.V. (%)	13.04

Table 15: Seed yield (kg/ha) in Soybean genotype.

Genotype		Seed yield (kg/ha)
G1	MAUS-162	1029.20
G2	MAUS-158	1125.00
G3	JS-93-05	847.42
G4	MAUS-612	945.69
G5	JS-335	637.04
G6	MAUS-81	717.54
G7	MAUS-71	1057.8
	G.M.	908.51
	S.E±	40.17
	C.D. at 5%	123.60
	C.V. (%)	7.66

Table 16: Biological yield (kg/ha) in Soybean genotype

Genotype		Biomass (kg/ ha)
G1	MAUS-162	3316.64
G2	MAUS-158	3879.12
G3	JS-93-05	2521.81
G4	MAUS-612	3232.90
G5	JS-335	2504.71
G6	MAUS-81	2622.31
G7	MAUS-71	3528.23
	G.M.	3086.52
	S.E±	230.13
	C.D. at 5%	708.05
	C.V. (%)	12.91

Table 17: Harvest index (%) in Soybean genotypes.

Genotype		Harvest index (%)
G1	MAUS-162	31.02
G2	MAUS-158	29.03
G3	JS-93-05	34.31
G4	MAUS-612	29.31
G5	JS-335	30.32
G6	MAUS-81	27.65
G7	MAUS-71	30.06
	G.M.	30.24
	S.E±	1.54
	C.D. at 5%	4.63
	C.V. (%)	6.16

Table 18: Days to 50% flowering in Soybean genotypes.

Genotype		Days to 50% flowering
G1	MAUS-162	43
G2	MAUS-158	39
G3	JS-93-05	39
G4	MAUS-612	39
G5	JS-335	38
G6	MAUS-81	40
G7	MAUS-71	38
	G.M.	40
	S.E±	1.81
	C.D. at 5%	5.43
	C.V. (%)	2.30

Table 19: Days to physiological maturity in Soybean genotypes.

Genotype		Days to physiological maturity
G1	MAUS-162	105
G2	MAUS-158	97
G3	JS-93-05	94
G4	MAUS-612	95
G5	JS-335	93
G6	MAUS-81	96
G7	MAUS-71	98
	G.M.	97
	S.E±	1.56
	C.D. at 5%	4.68
	C.V. (%)	1.94

e) Developing seed weight (gm)/pod

The Present study showed that the developing seed weight of soybean genotype recorded at different crop growth stages are presented in Table 9. The results revealed that developing seed weight was not significantly (at 5%) influenced at 65 & 75 DAS however it was significant at 85 DAS but observed a linear increase in developing seed from 65DAS,75DAS and 85 DAS as shown in (Table 9).

The results are in confirmatory with Devendra Vasht., (2016) [7]. The genotype obtained significantly maximum pod weight G3 (7.45) gram per plant followed by genotypes G6 (7.39) and G8 (7.16).

f) Weight of Pod wall (gm)

The Present study showed that the weight of pod wall of soybean genotype recorded at different crop growth stages are presented in Table 10. The results revealed weight of pod wall was significant (at 5%) among various genotypes at 65 DAS, 85 DAS and non significant at 75 DAS but observed a linear increase in weight of pod wall from 65DAS, 75DAS and 85 DAS as shown in (Table 10).

g) Number of pods/plant

The present result showed that the number of pods per plant ranged from 74.47 to 92.36. Genotypes G2 (92.36) exhibited significantly maximum number of pods per plant followed by genotypes G7 (87.89) and G1 (83.31) than rest of the genotypes. However, the minimum number of pods per plant was recorded in G5 (74.47).

The results are in confirmatory with. Adasul D.L., (2013) [2], Devendra Vasht., (2016) [4], Barskar *et al*., (2014) [5], Ratan Bahale., (2012) [4], Mane A.M., (2013) [10], Akbari and Peat (2001) reported that number of branches and pod per plant, number of seeds per pod, seed index, stem, leaf and seed dry weight and plant height were significant among genotypes.

h) Pods per node

The results showed that the pods per plant ranged from 3.97 to 6.08. Genotype G2 (6.08) had significantly higher number of pods per node at par with G1 (5.74) and G7 (5.34). However, genotype G5 (3.97) noted minimum pods per node.

These results are consistent with the study ofBarskar *et al*., (2014) [5], the perusal of the data revealed that higher PCV and GCV were recorded for number of clusters per plant followed by seed yield per plant, biological yield per plant, number of pods per plant and plant height.

i) Number of seeds/pod

In the present study revealed that the number of seeds per pod ranged from 2.92 to 3.46. Genotype G3 (3.46) exhibited maximum number of seeds per pod and was at par with G1 (2.86), G2 (2.93), G4 (2.92) and significantly superior over rest of the genotypes.

These result also supported by the study of Adasul D.L., (2013) [2], Devendra Vasht., (2016) [4], Barskar *et al*., (2014), Ratan Bahale., (2012) [4], Mane A.M., (2013) [10], Umesh Bhati., (2015) [14].

j) Dry matter (gm/plant)

At 65 DAS

Genotypes G2 (18.28) showed significantly higher total dry matter production followed by G3 (18.06), G6(18.07), and G7(18.24). The minimum was noted in genotype G5 (17.11).

At 75 DAS

Genotypes G2 (34.34) followed by G3(33.12), G4(32.12), G5(31.81), had significantly higher accumulation of TDM over rest of the genotypes. Genotype G1 (28.04) was associated with the lowest magnitude for this trait.

At 85 DAS

Genotypes G2 (34.28) followed by G7(34.28), G4 (34.08) and G3 (33.20) had significantly more total dry matter production. The minimum was recorded in G6 (31.28).

k) Seed Yield (g/plant)

In the present investigation the result showed that the seed yield per plant ranged from 8.90 to 14.12 gm per plant. Genotype G2 (14.12) significantly superseded rest of the genotypes for seed yield per plant and was at par with G7 (13.18), G1 (12.50) and G4 (12.21). Lowest seed yield was recorded in genotype G5 (8.90).

These results are consistent with the study of Adasul D.L., (2013) [2], Devendra Vasht., (2016) [7], Barskar *et al*., (2014) [5], Ratan Bahale., (2012) [4], Mane A.M., (2013) [10].

l) Seed yield (kg per ha)

In the present investigation the result showed that the seed yield per hectare ranged from 637.03 to 1125.00 kg per ha. Genotype G2 recorded highest seed yield (1125.0 Kg per ha) followed by G7 (1057.80 kg per ha) and G1 (1029.2 kg per ha). Lowest seed yield was recorded by G5 (637.04 kg per ha).

These results are consistent with the study of Adasul D.L., (2013) [2], Devendra Vasht., (2016) [7], Barskar *et al*., (2014) [5],Ratan Bahale., (2012) [4], Mane A.M., (2013) [10].

m) Biological yield (kg/ha)

In the present investigation the result showed that the biological yield was significantly maximum in genotypes G2 (3879.10) at par with G1 (3316.60), G4 (3232.90) and G7 (3528.20). The significantly minimum biological yield was recorded in genotype G5 (2504.7) and G3 (2521.80).

These results are consistent with the study of Adasul D.L., (2013) [2], Devendra Vasht., (2016) [7], Baraskar *et al*. (2014) [5], Ratan Bahale., (2012) [4], Mane A.M., (2013) [10], Umesh Bhati., (2015) [14]

n) Harvest index (%)

In the present investigation the result showed that the harvest index ranged from 27.65 to 34.31. Genotype G3 (34.31) exhibited maximum harvest index which was at par with genotypes G5 (30.32), G7 (30.06) and G1 (31.02). Minimum was calculated in G6 (27.65).

These results are consistent with the study of Adasul D.L., (2013) [2], Devendra Vasht., (2016) [7], Baraskar *et al*. (2014) [5], Ratan Bahale., (2012) [4], Mane A.M., (2013) [10].

Conclusion

It may concluded from this research work that the soybean genotype differed significantly in relation to their phonological, physiological, biochemical and structural yield attributing traits with biological and economic yield. The genotypes MAUS-158 and MAUS-71 accumulated physiological growth determinants *viz*; LA, LAI, LAD. The improvement in morpho physiological parameters resulted in maximum realisation of yield potential of MAUS-158 which finally resulted in maximum biological and economic yield.

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