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Accumulation and partitioning of dry matter and nutrients in soybean

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Abstract
A pot experiment was conducted to study the dry matter and nutrients accumulation pattern in soybean (cv. GJS-3) on clay soil (*Typic Heplustepts*) of Sagdividi Research Farm, Junagadh Agricultural University, Junagadh. The results showed that the maximum dry matter in plant (55.3 %) was accumulated during pod development stage. Soybean shoot showed higher accumulation of dry matter and nutrients, followed by seed and roots and shell, except N, and S which was higher in seed. The removal of nutrients was recorded in the ranges of 4.8 to 10.5, 35.1 to 79.4 and 11.2 to 60.1 per cent of the total requirement of different nutrients during vegetative, reproductive and pod development stages, respectively. The peak absorption of Ca, Mg, K, Fe and Mn took place during reproductive stage, that of N, K, and S, at pod development stages and Zn and Mn almost equally during reproductive and pod development stages.

Keywords: Accumulation and Partitioning, Dry matter, Nutrients and Soybean crop

Introduction
Soybean (*Glycin max* (L.) Merr.) is one of the most important oil seed legume crops of the world. Its seed contain 42-45% protein and 22% edible oil. It is considered as an important economic food legume cultivated worldwide because of its higher nutritional and industrial values. Soybean is a good source of protein, unsaturated fatty acids, minerals, vitamin A, vitamin B, vitamin C and vitamin D which can meet-up different nutritional needs of human and animals (Mondal *et al*., 2012) [7]. The pattern of accumulation of dry matter and nutrients at various stages of growth is a useful guide in evolving proper fertilization schedule. Limited work on nutrients distribution pattern in groundnut and wheat crops has been done by Patel and Zalawadia, (1982) [8], Polara *et al*., (1991) [9] and Polara *et al*, (2010) [10], but no work has been done on dry matter and nutrients accumulation in soybean crop in this region. In the present study the proportion of uptake of nutrients by soybean crop at various stages were studied to throw more light on the peak period of absorption of different nutrients during growth of soybean. This information may be useful to adjust the time of application of fertilizers to coincide with the period of maximum absorption of nutrients by soybean. The present investigation was performed to elucidate information on a variety (GJS-3) of soybean on this aspect.

Materials and methods
A bulk surface (0-30cm.) soil was collected from Central Experimental Research Farm, Junagadh Agricultural University, Junagadh. Experimental soil has $EC_{2.5}$ 0.05 (dSm^{-1}), $pH_{2.5}$ 7.8, $CaCO_3$ 75.5 g kg^{-1}, bulk density 1.55 g/cm^3, available N, P and K 80.4, 9.26 and 119.4 mg ka^{-1}, respectively. Pots having 30 cm diameter and 45 cm height were filled with 15 kg soil. Ten bold and healthy seeds of soybean ('GJS 3') were dibbled in each pot and five healthy plants per pot were maintained. The soybean crop was fertilized with 30 mg N kg^{-1} and 60 mg P_2O_5 kg^{-1} in the form of Urea and Di-ammonium Phosphate, respectively. Four replications were kept for each stage. The plants were samples at 25, 50 and 100 days after sowing (DAS) in order to compute dry matter yield during vegetative (0-25 DAS) reproductive (25-75DAS) and pod development (75-100 DAS) stages. The plant samples (shoot, root, seed and shell) were oven dried at 60º C to a constant weight to measure dry matter of different plant parts. The plants were analyzed for N, P, K, Ca, Mg, S, Fe, Mn, Zn and Cu as per standard methods (Jackson, 1973) [6] and uptake was calculated by multiplying with respective dry matter yield.

Results and discussion

Dry matter and nutrient accumulation in soybean during the first 25 days of growth were less but at 75 DAS, the crop accumulated 44.7 % dry matter and almost similar proportion of N (39.9 %), P (48.0 %), S (50.1 %), Zn (52.2) and Cu (55.3 %) and sufficient proportion of Ca (88.8 %) Mg (86.0 %), Fe (72.7 %), K (70.4 %) and Mn (65.9%) of the total accumulated was observed at harvest (Table 1). The shoot retains the major part of K, Ca, Mg and Fe accumulated during vegetative growth indicating their utilization for structural and developmental processes and allowed little translocation of K, with almost nil translocation of Ca and Mg towards reproductive parts. Hallock *et al.,* (1971) [4] also reported similar results in groundnut crop. With respect to growth stages, at maximum proportion of dry matter (55.3%), nitrogen (60.1 %), phosphorus (52.0 %) and sulphur (49.4 %), were accumulated during pod development stage (75-105 DAS), while in case of Calcium (79.4 %),Magnesium (76.5 %) potassium (63.2 %), iron (62.2 %) and manganese (58.0 %) during reproductive stage (25-75 DAS) and zinc and copper accumulated almost equally during reproductive (44.2 and 48.6 %) and pod development (47.8 and 44.7 %) stages (Table 2). The results reveal that the highest requirement of soybean to Ca, Mg, K and Fe was during reproductive stage. The shoot contains considerable N and P concentration indicates that soybean crop continued to absorbed N and P till maturity. Possibly, as these nutrients were translocated from leaves to the fruiting body through stem a part of them might have been retained in the stem (Chahal *et al*., 1983) [1]. Also observed peak absorption of Ca and Mg by groundnut during reproductive stage. The requirement of Zn and Cu by soybean throughout the period of crop growth, while that of N, P, K, S and Mn were higher during pod development stage. Polara *et al*. (1991) [9] was also reported that the maximum absorption of N and P by groundnut crop during pod development stage.

The maximum dry matter and nutrients were accumulated in shoot followed by seed, root and /or shell in all sampling dates (Table 3). Iron and zinc uptake by roots was as high as 33.4 and 36.4 % at 25 days and it gradually decreased to 10.9 and 10.3 %, respectively at harvest (100 DAS). With advancement in crop age, the dry matter and nutrients translocate to seed. The rates of translocation of N, P, K, S and Mn was higher than P, Ca, Mg, Fe, Zn and Cu. The higher accumulation of N, P and S in kernel at harvest. The S was high in seed where it was involved in S-containing amino acids, proteins and oil synthesis. Reported that the 50 to 55 per cent of N, P and S accumulation in groundnut pod. The above results are in close proximity with the findings of Coelho *et al.* (1967) [2] and Polara *et al*. (1991) [9] in groundnut crop and Hanway and Weber (1971) [3] in soybean crop.

Table 1: Dry matter and uptake of nutrients at different stages of soybean growth

Sampling stages	Dry matter yield (mg plant^{-1})	Nutrients uptake (mgplant^{-1})									
		N	P	K	S	Ca	Mg	Fe	Mn	Zn	Cu
25th day	885	29.5	4.7	11.8	3.6	5.3	4.0	0.30	0.106	0.044	0.017
	(4.4)	(4.8)	(7.0)	(7.2)	(9.0)	(9.4)	(9.5)	(10.4)	(8.0)	(8.0)	(6.6)
75th day	8890	247.6	32.1	115.6	20.2	49.9	36.3	2.08	0.875	0.290	0.141
	(44.7)	(39.9)	(48.0)	(70.4)	(50.1)	(88.8)	(86.0)	(72.7)	(65.9)	(52.2)	(55.3)
100th day	19876	621.4	66.8	164.2	39.8	56.2	42.2	2.86	1.327	0.556	0.255

( ) Figures in parenthesis indicate percentage values of total

Table 2: Pattern of dry matter and nutrients accumulation at different stages of soybean

Growth stage	Dry matter yield (mgplant^{-1})	Nutrients uptake (mgplant^{-1})									
		N	P	K	S	Ca	Mg	Fe	Mn	Zn	Cu
Vegetative stage (0-25 DAS*)	885	29.5	4.7	11.8	3.6	5.3	4.0	0.30	0.106	0.044	0.017
	(4.4)	(4.8)	(7.0)	(7.2)	(9.0)	(9.4)	(9.5)	(10.5)	(8.0)	(8.0)	(6.7)
Reproductive stage (25 -75 DAS)	8005	218.1	27.4	103.8	16.6	44.6	32.3	1.78	0.769	0.246	0.124
	(40.3)	(35.1)	(41.0)	(63.2)	(41.6)	(79.4)	(76.5)	(62.2)	(58.0)	(44.2)	(48.6)
Pod development stage (75 -100 DAS)	10986	373.8	34.7	48.6	19.6	6.3	5.9	0.78	0.452	0.266	0.114
	(55.3)	(60.1)	(52.0)	(29.6)	(49.4)	(11.2)	(14.0)	(27.3)	(34.0)	(47.8)	(44.7)
Total (At harvest)	19876	621.4	66.8	164.2	39.8	56.2	42.2	2.86	1.327	0.556	0.255

( ) Figures in parenthesis indicate percentage values of total

* DAS =Days after sowing

Table 3: Partitioning (per cent) of dry matter and nutrients to different plant parts of soybean.

Growth stage	Dry matter	Nutrients (%)									
Sampling stage		**N**	**P**	**K**	**S**	**Ca**	**Mg**	**Fe**	**Mn**	**Zn**	**Cu**
25th day											
Shoot	63.7	82.4	74.5	72.9	69.4	60.4	62.5	66.6	71.7	63.6	70.6
Root	36.3	17.6	25.5	27.1	30.6	39.6	37.5	33.4	28.3	36.4	29.4
75th day											
Shoot	74.7	75.6	73.3	81.5	74.2	77.4	72.7	80.5	77.2	74.2	70.7
Root	15.3	10.0	9.4	9.6	10.3	14.1	17.8	10.5	14.3	10.8	13.3
Pod (Immature)	10.0	14.4	17.3	8.9	15.5	8.5	9.5	9.0	8.5	15.0	16.0
100th day											
Shoot	42.9	38.9	47.9	67.5	40.5	72.2	61.2	62.1	67.3	43.0	44.3
Root	17.0	7.4	3.0	6.6	10.3	6.9	10.6	10.9	11.9	10.3	12.2
Seed	23.9	49.8	42.1	14.0	41.6	9.8	14.9	16.1	8.6	25.7	28.6
Shell	16.2	3.9	7.0	11.9	7.6	11.1	13.3	10.9	12.2	21.0	14.9

Conclusion

From the above results it can be concluded that the dry matter synthesis and accumulation of nutrients were interrelated. The pod development stage was found more important for dry matter and N, P and S accumulation and reproductive stage for Ca, Mg, Fe, K and Mn accumulation whereas, Zn and Cu was requirement throughout the growth period.

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