International Journal of Chemical Studies 2018; 6(5): 1738-1741

International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(5): 1738-1741

Received: 21-07-2018
Accepted: 24-08-2018

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Effect of drip fertigation on growth and yield of soybean

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Abstract
The field experiment was carried out at Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya Raipur (C.G.) during *Kharif* season of 2017 to evaluate the effect of drip fertigation on growth and yield of soybean. There were eight treatment T_1- 75% RDF through fertigation, T_2- 100% RDF through fertigation, T_3- 125% RDF through fertigation, T_4 - 75% RDF (25 % Basal + 75 % through fertigation), T_5-100% RDF (25 % Basal + 75 % through fertigation), T_6- 125% RDF (25 % Basal + 75 % through fertigation), T_7 -100% RDF through conventional application with drip irrigation, T_8- No fertilization with conventional irrigation. The experiment was laid out in randomized block design with eight treatments in three replications. Soybean variety JS 97-52 was sown at a spacing of 30 cm x 10 cm with seed rate of 65 kg ha^{-1}. The results of experiment indicated that various growth parameter like plant height at harvest, dry matter accumulation at 60 and 90 DAS recorded significantly maximum with the application of 125% RDF through fertigation (T_3). Application of 100% RDF through fertigation (T_2) produced significantly maximum number of pod plant^{-1}, number of seed pod^{-1}, number of seed plant^{-1}, 100 seed weight and seed yield (26.89 q ha^{-1}), while maximum stover yield (32.77) produced with the application of 125% RDF through fertigation (T_3) and the minimum growth, yield attributing character and yield were observed under no fertilization with conventional irrigation (T_8). In terms of economics, the maximum gross return (82025 Rs ha^{-1}), net return (49301 Rs ha^{-1}) and benefit: cost ratio (1.51) were recorded with the application of 100% RDF through fertigation (T_2).

Keywords: drip fertigation, growth, soybean

Introduction
Soybean [*Glycine max* (L.) Merrill] known as a wonder crop of 20th century because it contains about 20.5% carbohydrates, 20% oil with poly unsaturated fatty acids specially Omega 6 and Omega 3 fatty acid, 4.5% minerals, 3.7% fibre, 8.1% water and 43.2% protein, its protein contains all the essential amino acids such as Lysine, Leucine, Lecithin, therefore from nutritional point of view it is known as miracle crop (Chauhan *et al.* 1988) [4]. Soybean builds up the soil fertility by fixing atmospheric nitrogen (45 to 60 kg ha^{-1}) through the root nodules, and adds about 0.5 to 1.5 tonnes ha^{-1} organic matter in soil through leaf fall (Kanase *et al*. 2006) [5]. Among the soybean growing country the United State of America (117.20 M tonnes) is the highest producer of soybean in the world followed by Brazil (96.29 M tonnes), Argentina (58.79 M tonnes). These three countries dominate global production, accounting for 80% of the world's soybean supply (Annonymus, 2016a) [1], India is the fourth highest soybean producing country in the world, during 2000, soybean occupies an area of 6.41 million hectares which is now increased to 11.60 million hectares in 2015-16, while the production was 5.27 million tonnes and now it has been recorded to 8.57 million tonnes and the mean national productivity of the crop has decreased from 822 kg ha^{-1} to 738 kg ha^{-1}. The major soybean growing states are Madhya Pradesh (5.90 M ha), Maharashtra (3.70 M ha), Rajasthan (1.20 M ha), Andhra Pradesh, Telangana (0.24 M ha) and Karnataka (0.25 M ha). The crop is fast spreading in southern states such as Andhra Pradesh and Karnataka. Production of soybean in India is dominated by Maharashtra and Madhya Pradesh which contribute 89 % of the total production. Rajasthan, Andhra Pradesh, Karnataka, Chhattisgarh and Gujarat contribute the remaining 11% production.

In near future, several developing countries would face major challenge in achieving sustainable food security. Enhancing sustainable food production would require proper and judicious use of available land, water and fertilizer resources. This requires agricultural intensification with the emerging concept of fertigation, scientific usage of micro-irrigation with water-soluble fertilizers and prevention of soil pollution and restoration of soil health. Among the agronomic practices, nutrient and water management play a vital role in determining the yield and quality of the produce. Under these circumstances, cultural methods are to be modified and standardized according to the need of existing market windows and immediate attempts have to be made for maximizing the productivity of crops. This can be achieved through application of adequate quantity of the available water and fertilizers economically.

Drip fertigation is a recent innovative and hi-tech method receiving wider acceptance and adaptation, by which fertilizers are applied along with irrigation water through drip system to get higher fertilizer use efficiency besides enhancing the crop yields. Therefore, concerted efforts are now needed to harness the available quantities of water with fertilizer and put them to efficient use to achieve higher productivity per drop of available water and per unit of fertilizer application.

Materias and Methods

A field experiment was carried out during *kharif* season (June to October) of 2017 at Instructional cum Research Farm, IGKV, Raipur (C.G.). The climate of the location is sub-humid with hot summer and cold winter. The mean annual precipitation of the region is 1326 mm (based on 80 years mean), about 85% of rainfall is received during rainy season that is middle of June to September with occasional showers in winter and summer months. The weekly maximum temperature raises upto 46˚C during summer and minimum temperature drop down as low as 6˚C during winter season. The site was a double cropped irrigated upland with rice–chickpea, rice- wheat and soybean- mustard cropping system. The experiment was laid out in randomized block design with eight treatments in three replications. The treatment comprised T_1- 75% RDF through fertigation, T_2- 100% RDF through fertigation, T_3- 125% RDF through fertigation, T_4 - 75% RDF (25 % Basal + 75 % through fertigation), T_5-100% RDF (25 % Basal + 75 % through fertigation), T_6- 125% RDF (25 % Basal + 75 % through fertigation), T_7-100% RDF through conventional application with drip irrigation, T_8- no fertilization with conventional irrigation. The soil of experimental field was clayey in texture (*Vertisols*) with low N, high P and K content. The recommended dose of N, P_2O_5 and K_2O *i.e.* 20: 60: 30 Kg ha^{-1}. Fertilizer was applied as basal dose in the form of urea, single super phosphate and murate of potash. However nutrient from drip fertigation was applied in the form of urea, phosphoric acid and sulphate of potash as source of nitrogen, phosphorus and potassium. Fertilizers were applied with drip as per the treatment requirements. Soybean variety JS 97-52 was sown on 28th, June 2017 at a spacing of 30 cm x 10 cm with seed rate of 65 kg ha^{-1}. The crop was harvested on 13th, Oct 2017. Observations were recorded on five random competitive plants.

Results and Discussion

Growth parameters

Plant height

Plant height of soybean was recorded maximum (at harvest) with the application of 125% RDF through fertigation (T_3), however application of 125% RDF (25 % Basal + 75 % through fertigation) (T_6) and 100% RDF through fertigation (T_2) were found at par with T_3 and the minimum was registered under the treatment with no fertilization with conventional irrigation (T_8). Pandagare (2013) [6] also found that application of 150% dose of customized fertilizer (CF) recorded maximum plant height might be due to higher availability of nutrients, increased the cell division and cell enlargement resultant in inter node elongation which favoured the plant growth and increased the plant height.

Dry matter accumulation

Dry matter accumulation ($plant^{-1}$) of soybean was recorded at 30, 60, 90 DAS and at harvest and data are presented in Table 1. It was observed that dry matter accumulation increased upto the time of harvest. Significantly maximum dry matter accumulation was observed with the application of 125% RDF (25 % Basal + 75 % through fertigation) (T_6) at 30 DAS. At 60 and 90 DAS, significantly maximum dry matter accumulation was recorded with the application of 125% RDF through fertigation (T_3) and at harvest maximum dry matter accumulation was recorded with the application of 100% RDF through fertigation (T_2), however it was found comparable to treatment 125% RDF through fertigation (T_3) and 125% RDF (25 % Basal + 75 % through fertigation) (T_6). The minimum dry matter accumulation was recorded under no fertilization with conventional irrigation (T_8). The increase in plant height and branches helped in increasing the dry matter accumulation. Higher dry matter production was directly related to higher value of LAI at different crop growth stage which gives an indication of higher photosynthesis and better plant growth rate. It was reported that number of leaves and dry matter accumulation were directly correlated with plant height and number of branches (Wandekar *et al.*, 2005) [7].

Protein content and protein yield

The data of protein content (%) and protein yield (kg ha^{-1}) have been presented in Table 2. The protein content and protein yield was found significantly higher with the application of 125% RDF through fertigation (T_3), however it was found at par with the application of 125% RDF (25 % Basal + 75 % through fertigation) (T_6), 100% RDF through fertigation (T_2) and 100% RDF (25 % Basal + 75 % through fertigation) (T_5), while minimum protein content and protein yield was registered under no fertilization with conventional irrigation (T_8). The increase in nitrogen concentration might have resulted to increase the protein content. These results are supported by Morshed *et al.* (2008) [8] and Peric *et al.* (2009) [9].

Yield attributes and yield

Yield and yield attributing characters have been presented in table 2. The results from yield attributing characters indicated that significantly maximum number of pods, seeds pod^{-1}, seeds plant-^{1} and 100 – seed weight were found with the application of 100% RDF through fertigation (T_2), which was followed by 125% RDF through fertigation (T_3). The minimum pods $plant^{-1}$ and seeds $plant^{-1}$ were found under no fertilization with conventional irrigation (T_8).

Seed yield was found significantly maximum (26.89 q ha^{-1}) with the application of 100% RDF through fertigation (T_2), which was found at par with 125% RDF through fertigation (T_3), whereas maximum stover yield (32.77 q ha^{-1}) was found with the application of 125% RDF through fertigation (T_3), which was found at par with the application of 100% RDF through fertigation (T_2). Hence, the judicious and precise application of nutrient through fertigation is more important rather than the higher dose of nutrient application. The minimum seed and stover yield was noted under no fertilization with conventional irrigation (T_8). The harvest index (%) was found higher with the application of 100% RDF through fertigation (T_2) and the minimum harvest index (%) was found no fertilization with conventional irrigation (T_8). The adequate supply of nutrients might have facilitated for increasing the number of pods in plant. While, higher dose (150% or 125% dose of CF) of nutrients decreased the number of pods plant^{-1} might be due to excess vegetative growth which might have reduced the supply of photosynthetic material to sink. This is in accordance with the findings of Shafii *et al.* (2011) [11].

Economics

Economics data presented table number 3**.** The maximum cost of cultivation (36351 Rs ha^{-1}), was recorded with the application of 125% RDF through fertigation (T_3), while the maximum gross return (82025 Rs ha^{-1}), net return (49301 Rs ha^{-1}) and benefit: cost ratio (1.51) was recorded with the application of 100% RDF through fertigation (T_2) than rest of the other treatments. The increase in gross and net return obviously due to higher seed yield. Less input cost and higher economical yield may be resultant in increase the B: C ratio. Similar results were also reported by Vyas *et al*. (2006) [12] and Shivakumar *et al.* (2008) [10].

Table 1: Plant height at harvest and dry matter accumulation of soybean as influence by drip fertigation

Treatment		Plant height at harvest (cm)	Dry matter accumulation (g plant^{-1})			
			30 DAS	60 DAS	90 DAS	At harvest
T_1	75% RDF through fertigation	115.39	2.00	18.20	20.89	23.97
T_2	100% RDF through fertigation	121.71	2.61	20.79	24.09	29.41
T_3	125% RDF through fertigation	128.72	2.83	24.56	25.88	28.11
T_4	75% RDF (25 % Basal + 75 % through fertigation)	111.82	1.62	15.33	21.27	22.07
T_5	100% RDF (25 % Basal + 75 % through fertigation)	118.76	2.46	19.43	21.69	24.32
T_6	125% RDF (25 % Basal + 75 % through fertigation)	125.42	2.85	21.76	23.15	25.47
T_7	100% RDF through conventional application with drip irrigation	109.01	1.83	13.86	19.34	20.26
T_8	No fertilization with conventional irrigation	97.31	1.94	12.78	14.98	15.62
	SEm±	2.55	0.14	1.35	1.20	1.32
	CD(P=0.05)	7.73	0.43	4.08	3.65	4.01

Table 2: Yield attributing characters, yield and economics of soybean influence as by drip fertigation

Treatment		No. of pods plant^{-1}	No. of seeds pod^{-1}	No. of seeds plant^{-1}	100-seed weight (g)	Seed yield (q/ha)	Stover yield (q/ha)	Harvest index (%)	Protein content (%)	Protein yield (kg ha^{-1})	Total cost (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	B:C ratio
T_1	75% RDF through fertigation	76.07	3.72	248.18	11.98	21.75	26.49	45.03	29.13	639.96	29097	66333	37236	1.28
T_2	100% RDF through fertigation	90.29	4.12	329.07	12.90	26.89	29.05	48.10	30.29	814.91	32724	82025	49301	1.51
T_3	125% RDF through fertigation	88.07	3.90	302.53	12.76	24.63	32.77	42.93	33.71	830.29	36351	75112	38761	1.07
T_4	75% RDF (25 % Basal + 75 % through fertigation)	68.79	3.47	230.83	11.72	21.03	26.09	44.51	27.48	576.98	26939	64145	37207	1.38
T_5	100% RDF (25 % Basal + 75 % through fertigation)	78.55	3.84	262.36	12.11	22.40	27.23	45.12	29.60	672.01	29847	68325	38478	1.29
T_6	125% RDF (25 % Basal + 75 % through fertigation)	84.71	4.04	317.79	12.60	23.05	28.46	44.77	31.60	726.64	32754	70298	37544	1.15
T_7	100% RDF through conventional application with drip irrigation	62.11	3.25	220.98	11.21	17.14	25.82	39.84	26.79	456.90	21217	52286	31069	1.46
T_8	No fertilization with conventional irrigation	43.21	2.92	125.00	11.25	9.77	18.06	30.94	24.73	200.45	11491	24726	13235	1.15
	SEm±	3.43	0.24	9.63	0.57	1.20	1.39	2.13	1.47	54.23	-	3269.77	3269.77	0.17
	CD(P=0.05)	10.41	0.74	29.21	NS	3.64	4.23	6.47	4.46	164.48	-	9917.81	9917.81	0.50

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