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Effect of Irrigation Layouts and Foliar Nutrition on Grain Yield and Quality of Soybean

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ABSTRACT: *A field experiment was conducted during South West Monsoon (SWM) seasons of 1999 and 2000 to study the effect of different irrigation layouts viz., flat beds, flat ridges and furrows and ridges and furrows and foliar nutrition on yield, quality and nutrient uptake of soybean. The foliar nutrition consisted of combined application of nutrients (DAP (Di-ammonium phosphate), KCl and boron) and growth hormone (NAA-Napthalene acetic acid). Results indicated that grain yield was significantly higher under ridges and furrows during SWM 1999. Ridges and furrows resulted in higher mean grain yield of 1601 kg ha^{-1} which was 204 kg ha^{-1} higher over yield under flat beds. Foliar spraying of DAP 2%, KCl 1%, boron 0.2% and NAA 40 mg L^{-1} produced comparable results as that of foliar spraying of DAP 2%, KCl 1% and boron 0.2% during both seasons. The combined application of DAP, KCl, boron and NAA registered higher mean grain yield (1612 kg ha^{-1}) over DAP 2% (1423 kg ha^{-1}) and water spraying (1353 kg ha^{-1}) and was significantly higher over these two treatments during both the seasons. The irrigation layouts failed to produce any significant effect on seed quality and nutrient uptake. The protein content was significantly higher in foliar treatments receiving DAP either alone or in combination. The oil content recorded was higher due to foliar application of DAP and KCl with or without boron.*

INTRODUCTION

Soybean (*Glycine max* (L.) Merr.) is considered as a miracle golden bean of the millennium since it is nutritionally comparable to animal protein. On an average soybean seed contains 41% protein, 21% oil and 11% soluble carbohydrate (Openshaw and Hadley, 1984). However the growth of soybean is greatly affected by moisture availability at critical growth stages since this crop is sensitive to both excess and low soil moisture conditions. Thus the irrigation layouts have a definite effect on the growth and yield of the crop (Nalawade and More, 1993).

One of the major problems in increasing soybean productivity is incomplete filling of pods which can be offset through foliar application of nutrient combinations and growth regulating substances. The favourable effects of foliar application of either urea 2% or DAP 2% (Kalarani and Jeyakumar, 1998) and that of combined application of DAP 2% + KCl 1% (Ramesh, 1999) on effective seed filling and increased grain yield have been reported. Legumes have high boron requirement and suffer more frequently from boron deficiency. Also synergistic relationship of boron with nitrogen (Gascho, 1994) and potassium (Sakal *et al.*, 1988) has been reported. Furthermore the plant growth regulators like NAA are known to increase flowering, pod setting and grain filling in soybean (Deotale *et al.*, 1998). The combined foliar application of

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nutrients with NAA is found to have an enhanced effect compared to individual applications and also considered more economical (Thangaraj, 2000). Keeping this in view, the present investigation was carried out to study the effect of irrigation layouts and foliar spraying of nutrients and hormones on soybean.

MATERIALS AND METHODS

Field experiments were conducted at the farm of Tamil Nadu Agricultural University, Coimbatore during SWM seasons of 1999 and 2000. The farm is located at 11° N latitude and 77° E longitude at an elevation of 426.7 m above mean sea level. The mean monthly maximum and minimum temperatures are 33.6°C and 22.2°C, respectively. The soil was black clayey in nature classified taxonomically as Vertic Ustropept with physical and chemical properties of pH 7.8, EC 0.6 ds m^{-1}, clay 35.8%, silt 22.3%, coarse sand 17.5% fine sand 24.4 %, available N 235 kg ha^{-1}; available P_2O_5 14.7 kg ha^{-1} and available K_2O 795 kg ha^{-1}. Soybean variety (CO1) used in the study is a selection from Thailand variety (EC 39821) and is a determinate type, photo insensitive with cream coloured medium sized seeds.

The treatments consisted of three irrigation layouts viz., flat beds (M_1), flat ridges and furrows (M_2) and ridges and furrows (M_3) as main plots. The sub plots consisted of S_1- water spraying (control), S_2- DAP 2%, S_3- DAP 2% + KCl 1%, S_4- DAP 2% + KCl 1% + boron 0.2%, S_5- DAP 2% + KCl 1% + boron 0.2% + NAA 40 mg L^{-1}. The spraying was done once at 50 per cent flowering and a fortnight later and the crop was supplied with the recommended dose of fertilizers (20:80:40 kg NPK ha^{-1}). The experiments were laid out in split plot design and the treatments were replicated thrice.

Soybean seeds were dibbled in lines with a spacing of 30 cm between rows in flat beds. In flat ridges and furrows, two rows of seeds were sown along the top edge of the flat ridges formed 20 cm apart. In ridges and furrows, seeds were sown on either side of the ridges formed 30 cm apart, and with a common intra row spacing of 10 cm. In all the layouts the plant population was maintained constant.

The gross main plot size was 10 x 10 m^2. The flat beds were irrigated to a depth of 50 mm and subsequent irrigations were given when IW/CPE (Irrigation water/ Cumulative Pan Evaporation) ratio attained 0.60. Irrigation was scheduled whenever the cumulative pan evaporation readings reached 83 mm (50 mm/ 83 mm = 0.6). In flat ridges and furrows, irrigation water was let in through narrow channels of 20 cm wide and this consumed 16 mm of water for each irrigation. In the ridges and furrows treatment the consumption of water was 24 mm for each irrigation. The amount of irrigation water let into each plot was maintained at 3 L sec^{-1} by using an irrigation module fixed at the head end of the field. The amount of irrigation water let in each furrow of flat ridges and furrows and in ridges and furrows was quantified using a stop watch based on which the quantity of water consumed under each of these layouts was computed as 16mm and 24 mm, respectively.

At harvest, 10 plants were taken at random from each plot to determine yield components. Harvesting was done when the crop attained maturity by cutting the plants close to the ground. The seed protein and oil content were analyzed by using near-infrared analyzer and expressed in percentage.

RESULTS AND DISCUSSION

Yield components

The number of pods per plant was significantly influenced by irrigation layouts during SWM 1999. Ridges and furrows resulted in significantly higher number of pods per plant over flat ridges and furrows and were comparable with flat beds. A similar trend was also observed with regard to number of seeds per pod, which was significantly influenced during SWM 2000. However the irrigation layouts failed to influence the 100 seed weight (test weight) during both the seasons.

Foliar spraying of DAP 2 % + KCl 1 % + boron 0.2 % + NAA 40 mgL^{-1} produced significantly higher number of pods per plant, seeds per pod and 100 seed weight compared to spraying of DAP 2 % and water spraying during both seasons (Table 1). Inclusion of NAA 40 mg L^{-1} in the spray combination produced only comparable results as that of foliar spray of DAP 2 % + KCl 1% + boron 0.2 % during both the seasons studied.

Table 1. Effect of treatments on yield components of soybean.

Treatments	Number of pods per plant		Number of seeds per pod		Test weight (g)	
	1999	2000	1999	2000	1999	2000
Irrigation layouts						
M_1	89.97	92.25	2.58	2.47	11.40	11.72
M_2	82.81	90.82	2.63	2.41	11.11	11.21
M_3	92.69	92.38	2.72	2.57	11.36	11.57
SEd	1.22	1.63	0.06	0.04	0.23	0.31
CD	3.40	NS	NS	0.11	NS	NS
Foliar sprays						
S_1	86.49	87.64	2.38	2.11	10.47	10.72
S_2	86.85	90.83	2.50	2.37	11.04	11.36
S_3	87.89	92.90	2.71	2.60	11.56	11.63
S_4	89.91	92.88	2.80	2.70	11.58	11.88
S_5	91.30	94.82	2.82	2.64	11.79	11.89
SEd	1.58	1.22	0.05	0.04	0.14	0.10
CD	3.27	2.51	0.11	0.08	0.28	0.22

M_1- Flat beds M_2- Flat ridges and furrow M_3- Ridges and furrow
S_1-Control S_2-DAP 2% S_3- S_2 + KCl 1% S_4- S_3 + boron 0.2%
S_5-S_4 + NAA 40 mg L^{-1} CD – Critical Difference NS – Not Significant

Grain yield

The different irrigation layouts had a significant effect on grain yield of soybean in SWM 99. Ridges and furrows resulted in higher mean grain yield (1601 kg ha^{-1}) compared to the other layouts. The mean yield produced under flat beds was lower (1397 kg ha^{-1}) than the other two layouts. Ridges and furrows increased the yield by 204 and 111 kg ha^{-1} over flat beds and flat ridges and furrows respectively (Table 2). The combined application of DAP, KCl, boron and NAA and treatment combination of DAP, KCl and boron registered significantly higher values of grain

yield over other combinations (1612 and 1592 kg ha^{-1}) and were comparable with each other. Water spraying resulted in lower yield of 1353 kg ha^{-1}.

Table 2. Effect of treatments on grain yield (kg ha^{-1}) of soybean.

Treatments	Grain yield (kg ha^{-1})		
	1999	2000	Mean
	Irrigation layouts		
M_1	1376	1419	1397
M_2	1481	1499	1490
M_3	1529	1673	1601
SEd	16.02	88.75	
CD	44.49	NS	
	Foliar sprays		
S_1	1312	1395	1353
S_2	1375	1472	1423
S_3	1452	1548	1500
S_4	1574	1610	1592
S_5	1597	1627	1612
SEd	13.82	51.42	
CD	28.52	106.13	

M_1- Flat beds M_2- Flat ridges and furrows M_3- Ridges and furrows
S_1-Control S_2-DAP 2% S_3- S_2 + KCl 1% S_4- S_3 + boron 0.2%
S_5-S_4 + NAA CD – Critical Difference NS – Not Significant

Table 3. Effect of treatments on seed quality parameters of soybean.

Treatments	Protein content (%)		Oil content (%)	
	1999	2000	1999	2000
	Irrigation layouts			
M_1	40.17	40.35	19.23	19.69
M_2	39.97	40.47	18.90	19.74
M_3	40.57	40.31	19.14	20.41
SEd	0.33	0.10	0.17	0.12
CD	NS	NS	NS	0.33
	Foliar sprays			
S_1	39.72	39.37	18.65	19.28
S_2	40.72	40.76	18.99	19.68
S_3	40.17	40.64	19.45	20.29
S_4	40.34	40.57	19.28	20.37
S_5	40.22	40.54	19.08	20.12
SEd	0.38	0.21	0.16	0.27
CD	NS	0.44	0.33	0.55

M_1- Flat bed M_2- Flat ridges and furrows M_3-Ridges and furrows
S_1-Control S_2-DAP 2% S_3- S_2 + KCl 1% S_4- S_3 + boron 0.2%
S_5-S_4 + NAA CD – Critical Difference NS – Not Significant

Seed quality

Irrigation layouts failed to influence the protein content of soybean in both the seasons. The nutrient sprays had a significant effect on protein content in the SWM 2000. Among the nutrient combinations compared, foliar spray treatments including DAP (S_2, S_3, S_4 and S_5) recorded significantly higher content of protein as compared to water spray and were on par with each other (Table 3).

The oil content of soybean seeds was significantly influenced by the different irrigation layouts only in SWM 2000. The ridges and furrow method was significantly superior over other layouts in its effect on oil content. The different nutrient combinations produced significant effect on oil content in both the seasons studied. The combination of DAP, KCl and boron produced significantly higher oil content over DAP and water sprayed treatment (Table 3).

The favourable influence of ridges and furrows on yield of pulse crops has been reported by Singh *et al.* (1998), Rajagopal *et al.* (1995), Lawand *et al.* (1993) and Okada *et al.* (1991). They observed that ridge making loosened soil, increased infiltration and percolation of water and restricted water impounding in field.

The foliar application of different nutrient combinations had a significant influence on grain yield in both the seasons. Similar findings were reported by Ravankar *et al.* (1998). Significant response of soybean to foliar application of nutrients might be due to maximum uptake of minerals at early flowering and better nutrient balance in the plants by supplementing nutrients through foliage, leading to increased yield components. The favourable influence of potassium in combination with boron was earlier reported by Wu (1999). The results obtained in this study are in good agreement to those reported by Ingle *et al.* (1999).

The results indicate that supplementation of KCl, boron, NAA with DAP does not significantly increase protein content over application of DAP alone. The increase in seed protein content due to DAP application may be due to the increased supply of N through DAP, which is in line with the findings of Mercadopineda *et al.* (1988).

Increased oil content with foliar spray of DAP and KCl may be due to enhanced uptake of P and K. Increased P and K concentrations in the plants would aid in photosynthesis, accelerate nutrient uptake and subsequently translocation into sink as an oil (Rajamohan and Moosasherif, 1991). The supremacy of K established in increasing oil content is in confirmation with findings of Massay (1973). Boron was also found to be effective in increasing the oil content, which confirm the results reported by Chandel *et al.* (1989) but NAA had no effect on oil content.

CONCLUSIONS

Ridges and furrows resulted in higher mean grain yield over the adoption of flat beds and flat ridges and furrows. The foliar application of a combination of nutrients including DAP 2%, KCl 1%, boron 0.2% and NAA 40 mg L^{-1} resulted in higher pod formation, improved seed filling, test weight and hence in increased grain yield. This treatment was found to be comparable with the combination exclusive of NAA. The seed quality in terms of protein content increased due to inclusion of DAP, but indicated no response to supplementation with KCl, boron and NAA. However the

oil content improved due to foliar application of a combination of DAP 2% + KCl 1% with or without boron 0.2%.

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