Indian J. Soil Cons., 36 (1) : 42-47, 2008

Performance of Phalsa (*Grewia subinaequalis* Lin.) through integrated nutrient and canopy management on saline soils of the Indo-Gangetic plains

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ABSTRACT: *Phalsa* (*G. subinaequalis* Lin.) is a lesser known fruit suitable for cultivation in tropical to sub-tropical wastelands. It is a fruit with potential for value addition. Fresh fruits are rich in medicinal properties. An experiment was conducted to optimize integrated use of farm yard manure (FYM) and chemical fertilizers with canopy management by heading back of plants to improve vigour, yield and quality of phalsa raised on saline soils of the Indo-Gangetic plains. The study consisted of four treatments of varying proportions of FYM & NPK supplied through inorganic sources, with four levels of canopy management. Results revealed that *phalsa* plants fertilized with 25 kg FYM + 50:15:25 g of NPK plant^{-1} recorded significant increase in fruit yield and total soluble solids by 27 % & 12 % and 32% & 13% respectively, than other treatments, while bushes manured with 20 kg FYM + 50:15:25 g NPK (T_2) showed significant increase in fruit yield and total soluble solids by 12.5% and 13% respectively, than other treatments. Phalsa plants headed back to 100 cm height (P_2) significantly increased fruit yield by 68.8%, 32.4 %, 17.8 % and total soluble solids by 42%, 30 % and 14.4 % over P_0, P_1 and P_3, respectively. However, bushes headed back to 50 cm height significantly improved fruit yield by 26.7 % and total soluble solids by 10 % over control. It was concluded that application of 25 kg FYM and NPK in a ratio of 50:15:10 gm per plant and heading back the bushes to 100 cm height significantly improved plant performance, fruit yield and fruit quality.

Key words: Fruit yield and quality; Inorganic fertilizers; Organic manures; Pruning levels.

Phalsa (*Grewia subinaequalis* Lin.), an indigenous perennial bush, is a hardy minor fruit and can be grown successfully under rainfed conditions on marginal, sub-marginal and saline soils under rainfed conditions through minimum use of inputs. *Phalsa* bears small roundish pinkish fruits called berry that are used as table fruits, has medicinal properties and can be further processed for preparation of sherbet and squash. Its cultivation is confined to cities and towns mainly due to its short shelf life and necessity for quick marketing. The total fruit production in India is about 49.50 million tones, but fruit availability per capita is far below (40 g) the recommended dietary schedule of 120 g per day per person.

A large area (> 7 million hectares) is affected by salinity and alkalinity and is lying fallow or is under restricted cultivation. The presence of excess soluble salts in the soil is a serious deterrent to the successful cultivation of crops. These areas can be put under cultivation with salt tolerant fruit species like *phalsa*, with some improved technologies of integrated plant nutrient and canopy management for enhancing fruit yields. Some fruit species like *Emblica officinalis, Aegle marmelos, Psidium guajava, Syzygium cuminii, Carrissa carandus* and *Grewia subinaequalis* have been successfully grown in alkali soils with pH ranging from 9.2 to 10.5 after soil amendments (Singh *et al.*, 1986).Phalsa has been rated as a salt tolerant fruit species (Awasthi, 1997). Salt tolerance of fruit crops varies from species to species and even among cultivars of the same species. However, no systematic work has been done with respect to integrated nutrient management and canopy manipulations of *phalsa* as influenced by salinity.

Farmyard manure (FYM) is an excellent and balanced source of nutrients, which improves yield and quality of fruits, soil health and increase nutrient uptake (Abusaleha and Shanmugavelu, 1992). Incorporation of organic material in the form of FYM enhances the soil organic C content and has direct and indirect effects on soil properties and processes (Kundu *et al.* 2002., Katyal *et al.* 1997).

Nitrogen governs plant growth by virtue of being a major constituent of chlorophyll, protein, amino acids and photosynthetic activity. Phosphorus is crucial mainly for root

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growth and their ramification which ultimately governs uptake of soil mineral nutrients and moisture. Potash activates plant physiology, improves fruit quality, increases disease resistance, prevents lodging and makes the plants capable of surviving moisture stress. Addition of these essential nutrients and their uptake by plants has a considerable influence on growth and fruit yield, both qualitatively and quantitatively. Therefore, for attaining balanced nutrition, chemical fertilizers need to be integrated with farm yard manure for supplementing essential elements.

Canopy management is done to make the plant more productive and bear quality fruits, increase longevity of plants, to obtain a more manageable shape and get maximum returns. Heading back of plants to manipulate the plant canopy is an essential operation since flowering and fruiting takes place in the leaf axil on current growth to improve new growth, fruit yield, ripening and fruit quality (Singh, 1974). Accordingly, the present study was initiated to optimize fertilization through various integrated nutrient management options and canopy management for improved growth, fruit set, yield and quality of *phalsa* on saline soils.

MATERIAL AND METHODS

The study was conducted at C. S. Azad University of Agricultural and Technology, Kanpur (U.P.) during 1998-99 (latitude 25°26' and 26°38' north and longitude 79°31' and 80°34' east) situated at 179 m above sea level with a mean annual rainfall of about 850 mm. Soil has a pH of 7.9, electrical conductivity of 5.0 dSm^{-1} and contains 101 kg ha^{-1} of available nitrogen, 81 kg ha^{-1} phosphorus and 127 kg ha^{-1} potash. *Phalsa* was planted at a spacing of 2 X 2 m in square geometry and the study was carried out on a four year old orchard raised under subtropical climate.

FYM and inorganic fertilizers (nitrogen, phosphorus and potash were supplemented through urea, di-ammonium phosphate and murate of potash, respectively) were applied immediately after heading back of *phalsa* bushes in the 1st week of March each year. The following treatment specifications were applied : T_1 - 15 kg FYM + 50:15:10 g NPK, T_2 - 20 kg FYM + 50:15:10 g NPK and T_3 - 25 kg FYM + 50:15:10 g NPK. Phosphorus and potassic fertilizers + 50% N was applied as basal dose in March while remaining N was applied in September through placement near roots of *phalsa* bushes. Plant canopy was manipulated by heading back the bushes to a height of 50, 100 and 150 cm from the ground level with the help of secateur giving a slanting cut on the shoot tip as per the treatment specifications.

The study was conducted in a randomized block design with four replications. Three irrigations were applied at monthly interval from March to May in view of salinity levels of soil. Weekly data on canopy volume, numbers of shoots $bush^{-1}$, plant height and leaf $shoot^{-1}$ were recorded. Data on fruit weight, number of pickings, fruit yield $bush^{-1}$, juice %, pulp seed ratio, total soluble solids and reducing sugar were recorded to assess physical and chemical composition of fruits. Total soluble solids content of fruit was estimated through a hand refractometer calibrated in °Brix at 20°C. Canopy volume (m^3) was computed using $\pi r^2 h$ (where π = 22/7, r = canopy radius and h = canopy height). *Phalsa* was grown following uniform recommended package of cultural and management practices like weeding, chemical sprayings, watering, fertilizer application etc. other than the canopy manipulation and integrated use of organic with inorganic inputs. Cost of seedlings, land preparation, pit digging and refilling, manuring, planting of seedling, weeding and watch and ward till the time of disposal of fruits were taken into account for economic analysis.

RESULTS AND DISCUSSION

Analysis of results revealed that integrated nutrient and canopy management significantly influenced growth parameters, fruit yield and quality which are discussed below:

Vegetative growth

Data revealed that various treatments significantly influenced vegetative growth in terms of leaves $shoot^{-1}$, canopy volume, shoots $bush^{-1}$ and bush height (Table 1). Maximum number of leaves $shoot^{-1}$ (33), canopy volume (3.80 m3), shoots $bush^{-1}$ (73) and bush height (4.41 m) were recorded under T_3 treatment as compared to T_1 treatment, where minimum leaves $shoot^{-1}$ (25), canopy volume (1.13 m^3), shoots $bush^{-1}$ (66) and bush height (3.6 m) were observed. Improved vegetative growth (leaves $shoot^{-1}$, canopy volume, shoots $bush^{-1}$ and bush height) was noticed in plant where essential nutrients were supplied through integrated nutrient management along with farm yard manure @ 25 kg + NPK 50:15:10 g $plant^{-1}$. Addition of FYM might have increased buffering capacity of soil to convert soluble salts of calcium chlorides and calcium sulphates into insoluble form and also

Table 1. *Effect of integrated nutrient and canopy management on vegetative growth and fruit yield of phalsa.*

Treatments	Number of leaves shoot^{-1}	canopy volume (m^3)	Number of shoot bush^{-1}	Plant height (m)	Number of pickings	Fruit yield (kg) bush^{-1}
Integrated Nutrient Management (IPNM)						
T_1	25	1.13	66	3.60	5	2.00
T_2	28	3.02	69	3.90	5	2.25
T_3	32	3.80	73	4.41	6	2.75
C.D (5%)	1.21	0.09	2.01	0.22	0.59	0.19
Canopy Management						
P_0	21	0.79	62	3.00	4	1.46
P_1	26	2.55	65	3.54	5	1.85
P_2	31	4.91	70	3.91	6	2.45
P_3	28	3.14	68	3.11	6	2.08
C.D (5%)	0.89	0.08	2.92	0.29	0.83	0.21

IPNM (T_1 = 15 kg FYM + 50:15:10 g NPK, T_2 = 20 kg FYM + 50:15:10 g NPK and T_3 = 25 kg FYM + 50:15:10 g NPK) and Canopy management (P_0 = control, P_1 = 50 cm, P_2 =100 cm and P_3 = 150 cm from ground level)

improved soil properties like soil temperature, soil aeration, pH, microbial activities etc., that have improved root growth and proliferation for absorption of essential elements required by the plants. It is reported that organic manures improve the soil properties affected by salinity and make them favourable for plant growth (Talasilkar *et al.* 1999).

Results (Table 1) revealed that the growth parameters varied significantly under different levels of canopy manipulation. Maximum number of leaves shoot^{-1} (31), canopy volume (4.91 m^3), shoots bush^{-1} (70) and bush height (3.91 m) were noticed when plants were headed back to 100 cm from ground level, followed by those that were headed back to 150 cm and to 50 cm, while lowest values were recorded with control. It is observed that. due to good vegetative growth and canopy volume, higher leaf and growth area were encouraged leading to more food reserves in the cane that gave rise to maximum number of shoots in bushes headed back to 100 cm, than all other heading back levels. Tomkins and Shaulis (1988) reported that large size cane in grape has greater capacity to manufacture food than small or weak cane. Kumar and Reddy (2001) reported similar findings in grape by alternate pruning at Bangalore.

Fruit yield and physical parameters

Fruit yield bush^{-1}, number of pickings, fruit weight and pulp seed ratio varied significantly with use of fertilizers and farm yard manure (Table. 1 and 2). Maximum fruit yield bush^{-1} (2.75 kg), number of pickings (7), fruit weight (64.70 g) and pulp seed ratio (13.0) were registered in treatment that received FYM @ 25 kg + NPK 50: 15:10 g plant^{-1} where as plant supplied with FYM @ 15 kg + NPK 50: 15:10g plant^{-1} produced lowest fruit yield per bush (2), number of pickings(5), fruit weight (56 g) and pulp seed ratio (7.6). This may be attributed to more vegetative growth noticed in T_3 treatment due to higher root proliferation due to improved buffering capacity in soil by

Table 2. *Effect of integrated nutrient and canopy management on fruit quality of phalsa.*

Treatments	Fruit weight of 100 berries (g)	Pulp : seed ratio	Juice (%)	T.S.S (°Brix)	Reducing sugar (%)
Integrated Plant Nutrient Management (IPNM)					
T_1	56.8	7.6	46.10	15.86	6.60
T_2	58.1	10.0	49.92	17.92	7.11
T_3	64.7	13.0	52.50	21.00	11.01
C.D (5%)	0.36	2.20	0.68	2.01	3.35
Canopy management					
P_0	56.73	7.0	45.40	14.40	6.03
P_1	57.81	10.2	47.95	15.80	7.58
P_2	62.60	12.2	51.68	20.45	10.84
P_3	59.71	10.5	50.80	17.88	9.66
C.D (5%)	0.40	2.12	0.77	2.30	0.28

application of farm yard manure with chemical fertilizers. Salinity can be reduced by manuring with application of organic inputs (Abusaleha *et al.* 1992). Studies have revealed that integrated form of organic and inorganic manures improved soil properties and made favourable for growth and development of roots and improved absorption of essential nutrients in okra (Singh and Singh 1995)

Data (Table 1 & 2) revealed that fruit yield, pickings, fruit weight and pulp seed ratio improved significantly with different levels of canopy management. Maximum fruit yield, number of pickings, fruit weight and pulp seed ratio of 2.45 kg bush^{-1}, 6, 62.60 g and 12.2 respectively, were noticed under P_2 treatment (bushes headed back to 100 cm from ground level) followed by 2.08 kg bush^{-1}, 6, 59.71g and 10.5, respectively in P_3 treatment (headed back to 150 cm from ground level), while minimum fruit yield, number of pickings, fruit weight and pulp seed ratio 1.46 kg bush^{-1}, 4, 56.73 g and 7.0, respectively were observed in control. This can be attributed to longer shoots in plants that were headed back to 100 cm. which in turn gave rise to more number of fruiting nodes, and increased vigour of shoots. Higher number of leaves resulted in more carbohydrate assimilation that led to the increase in fruit yield and number of pickings. Balakrishnan *et al.* (1988) and Danial (2002) reported that canopy manipulation improved fruit yield and quality in case of grape and ber, raised on saline soil, respectively, while Talukdar (2003) reported similar results in *aonla*.

Fruit quality

Juice (%), T.S.S (^{0}Brix) and reducing sugars improved significantly through use of organic manure and inorganic fertilizers. Application of FYM and NPK @ 25 kg & 50:15:10 g plant^{-1} resulted in better fruit quality in terms of juice content (52.5%), T.S.S (21.0^0 Brix) and reducing sugar (11%) as compared to T_1 treatment where the lowest values of juice (46%), T.S.S (15.86^0 Brix) and reducing sugar (6.6%) were observed. The application of FYM @ 25 kg along with NPK in a ratio of 50:15:10g might have moderated soil properties like soil temperature, soil aeration, pH, enhanced microbial activities that have directly influenced fruit quality.

Results indicate that fruit quality in term of fruit juice content, T.S.S and reducing sugar varied significantly under different levels of canopy manipulation. Maximum fruit juice content (53.8%), T.S.S (20.45^0 Brix) and reducing sugar (11.84%) were recorded when bush canopy was headed back to 100 cm from ground level, while minimum fruit juice content (45.4%), T.S.S (14.40^0 Brix) and reducing sugar (6%) were observed in control (Table 2). Canopy management improved vegetative growth, leaf size, leaf numbers and bush volume which enhanced fruit size, fruit yield, juice percentage, TSS, reducing sugars and pulp content. Tomkins and Shaulis (1988) reported that greater the length of pruning, higher was the fruit yield obtained in grape.

Economic viability of *phalsa* cultivation

Economic viability of any system is very important tool for adoption of technology by the growers of the region. Hence all the parameters were taken into account for calculation of net return on per hectare basis. The cost of seedlings, land preparation, pit digging and refilling, manuring, planting of seedlings, weeding, watch and ward till the time of disposal of fruits were taken into account. Fruits were

Table 3. *Economics of integrated nutrient and canopy management in phalsa.*

Treatments	Fruit Yield (Kg bush^{-1})	Fruit yield (t ha^{-1})	*Total Expenditure (Rs. ha^{-1})	Gross income (Rs. ha^{-1})	Net benefit (Rs. ha^{-1})
Integrated plant nutrient management (IPNM)					
Control	1.46	3.65	9124	29200	20076
P_1	1.85	4.63	15586	37040	24454
P_2	2.45	6.13	15586	49040	34454
P_3	2.08	5.20	15586	41600	29014
Canopy management					
T_1	2.01	5.03	10831	40240	29409
T_3	2.25	5.63	11162	45040	33878
T_2	2.75	6.88	12331	47040	34709

IPNM (T_1 - 15 kg FYM + 50:15:10 g NPK, T_2 - 20 kg FYM + 50:15:10 g NPK and T_3 - 25 kg FYM + 50:15:10 g NPK) and Canopy management (P_0 - control, P_1 - 50 cm, P_2 -100 cm and P_3 - 150 cm from ground level)

*Total expenditure (Rs.) includes one time pruning charges, harvesting of fruits charges (5 no. of pluckings) @ Rs.100 man day^{-1} and transportation charges @ Rs. 500 for one time for the base year 1999. Charges of pit digging and planting (@ Rs.75 manday^{-1}), cost of seedling @ Rs.5 were taken into account for the reference year 1994-95.

auctioned at the prevailing market rate (Rs.8.0 kg^{-1}) which growers were fetching. The maximum net return of Rs. 34709, 33878 and 29409 ha^{-1} was obtained from treatments of T_3, T_2 and T_1 of integrated nutrient managements where as Rs.34454, 29014, 24454 and 20076 ha^{-1} were obtained from P_2, P_3, P_1 and P_0 canopy management treatments, respectively (Table. 3).

The potential areas where *phalsa* can be grown in U.P. state have been depicted in Fig.1. Since it is not possible to spatially segregate saline and alkaline soils on a map, only the areas where salt toxicity exists have been shown. An area of nearly 4334 sq. kms spread over 28 districts is affected by varying levels of salt toxicity and need special rehabilitation measures. The worst affected districts are Raebarelli, Pratapgarh, Unnao, Sultanpur and Jaunpur where 15.3, 4.2, 8.4, 6.4 and 5.1% of the districts total geographical area is affected by varying levels of salt toxicity. To facilitate a field worker to quickly identify areas affected by saline and alkaline problem, distinguishing features of these soils have been given in Table 4.

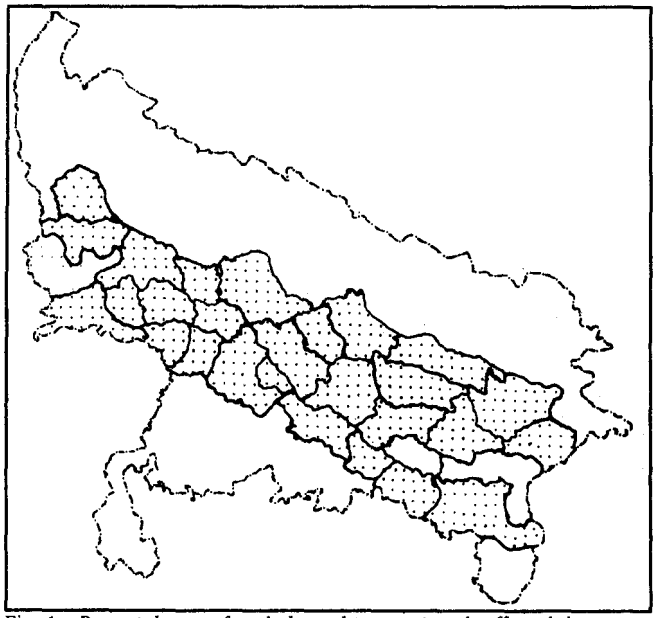

Fig. 1. *Potential areas for phalsa cultivation in salt affected districts in U.P.*

CONCLUSION

It can be concluded that the treatment where 25 kg FYM + 50:15:10 g NPK $plant^{-1}$ was applied, resulted in accelerated vegetative growth, improved fruit yield and fruit quality of *phalsa* and provided maximum net return of Rs.34709 ha^{-1}. Canopy management practiced by heading back bushes to 100 cm height resulted in significant increase in fruit yield as well as fruit quality, leading to a net return of Rs. 34454 ha^{-1}. *Phalsa* cultivation in saline soils is a remunerative preposition which can be successfully practiced in 28 districts of U.P. with a substantial area under as saline and alkaline soils and can provide additional income to small and marginal farmers.

Table 4. *Distinguishing features of saline alkaline soils*

Soil type	pH	ESP%*	EC (dSm^{-1})	Major features
Sodic (alkali)soil	8.5–10.6	>15	<4	High amounts of $CaCO_3$, Availability of N, Ca, Zn and Fe is low. No deficiency of P & K. $CaCO_3$ acts as a physical barrier for root growth
Saline soils	<8.2	<15	>4	Mainly consists of chlorides and sulphates of Na, Ca and Mg. Plant growth affected due to high osmotic pressure of soluble salts

*ESP – Exchangeable sodium %; EC – Electrical conductivity

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Received : March 2008; Revised : April 2008; Rerevised : May 2008 ; Accepted : May 2008