Effect of Foliar Nutrition of Water Soluble Fertilizers on Crop Growth, Yield and Economics of Mustard under Semi-arid Conditions

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ABSTRACT

A field experiment was conducted during Rabi 2018-19 at Rajasthan Agricultural Research Institute (SKNAU, Jobner), Durgapura, Jaipur, India to study the effect of water soluble fertilizers on crop growth, yield attributing characters, yield and economics of mustard under semi-arid conditions. The experiment was conducted in Randomized Block Design with 10 treatments in three replications. Different concentrations of water-soluble fertilizers in different combinations alongwith the recommended dose of fertilizers (RDF) was applied through foliar nutrition to the crop. The results of the study revealed that application of RDF along with first spray1.0 % urea phosphate+ 2nd spray of 2.0 % urea phosphate with SOP and 3rd spray of 2.0% SOP recorded significantly higher growth, yield attributing characters, yield, net returns and benefit cost ratio over recommended dose of fertilizer. Highest seed yield (3567kg ha-1) was recorded with application of RDF along with foliar applications of 1.0 % UP+ 2nd spray of 2.0 % UPSOP and 3rd spray of 2.0% SOP which was 27.3% higher than yields obtained in RDF alone. Highest Net Monetary Return (Rs.127121/ha) and B:C Ratio (3.37) was also recorded with application of RDF along with first spray of 1.0 % UP+ 2nd spray of 2.0 % UPSOP and 3rd spray of 2.0% SOP.

Key words: *Water soluble fertilizers; Mustard; Yield; Economics;*

Mustard crop occupied 36.54 million hectares area, 72.80 million metric tonnes production with the productivity of 1990 kg/ha in the world during the year 2018-2019*(USDA, 2019)*. In India, Rajasthan, Uttar Pradesh, Madhya Pradesh, Haryana and Gujarat are the highest sown states accounting for about more than 70 per cent of total mustard acreage in the country. Area production and productivity of mustard in India accounted for about 7.20 million hectares, 8.00 million metric tons, 1110kg/ha, respectively in the year 2018-2019 *(USDA, 2019)*. Generally, pulse and oilseed crops are raised under rainfed conditions with low input and poor management practices leading to lower productivity level *(Lal et al., 2015)*. Low organic carbon, multi nutrient deficiency, skewed nutrient application, low organic matter status, lack of knowledge and innovation in product development have posed tremendous challenge in crop nutrition solution. Intensification of agriculture coupled with use of high analysis fertilizers, devoid of secondary and micronutrients has led to widespread deficiency of these nutrients which has further aggravated the situation because of restricted or no application of organic manures. The deficiency of sulphur, zinc and boron is very common in many states. Imbalance nutrition is one of the important constraints towards higher mustard productivity, oil content and other quality parameters *(Lal et al., 2016)*. Role of balanced nutrient management and conservation of natural resource has increased manifold to ensure sustainability. Inorganic and organic fertilizer can be

found in different types of products like compound, straight, controlled released, blended, granulated, water soluble and liquid fertilizer *(Srivastava et al., 2014, 2015).*Soil application of organic and inorganic nutrients results in improvement in yield, nutrient uptake and soil nutrient status after harvest *(Manasa et al., 2015)*.

Recently, new generation special fertilizers have been introduced exclusively for foliar feeding and fertilization. Foliar application of nutrients is effective in supplementing high nutrient demand at some crucial crop growth stages, correcting nutrient deficiencies in field crops. These fertilizers have different ratios of N, P and K which are highly water soluble and so applicable for foliar application *(Jayabal et al., 1999).*Foliar nutrition to crops improves the nutrient use efficiency reduces the problems like fixation and immobilization of nutrients resulting in increased nutrient uptake. Hence, foliar nutrition is important alternative of fertilization in modern agriculture. In this method more utilization of nutrients occurs more efficiently and correcting nutrient deficiencies rapidly. Above all, unlike conventional soil applied fertilizers, WSF's because of its higher efficiencies a drastic reduction in soil pollution is expected. Water soluble fertilizers are generally considered 100% soluble in water having low salt index to reduce the potential for burning of plant tissue and suitable for foliar application or fertigation. RDF can be reduced to 85% by supplying nutrients through organics and foliar spray. Yield potentials of the crop, can be realized by balanced and efficient use of organic and inorganic sources of nutrient *(Meena et al., 2016)* and also use of suitable agronomic package practices to crop. Several studies conducted on various crops over the world and India revealed that, retention of flowers is possible through foliar application of growth regulators and essential nutrients during flower initiation and pod formation stages along with soil application of nutrients *(Chaurasia et al., 2005)*. Hence, the present study was conducted to with the objective to evaluate the effect of application of water soluble nutrients through foliar sprays along with soil application is able to supplement the nutritional requirements of crops.

METODOLOGY

Experimental site, design and treatment: A field experiment was carried out at Research farm of Rajasthan Agricultural Research Institute, Durgapura, Jaipur, (SKNAU, Jobner), Rajasthan, India during *Rabi* season of 2018-19 to examine the effect of foliar application of different 100 % water soluble fertilizers on growth, yield and economics of mustard under semi-arid conditions of Rajasthan. The experimental site was located at 26°512 N latitude and 75°472E longitude and at an altitude of 390 m above mean sea level. The mean maximum temperature varied from 19.8 to 36.1 °C and minimum temperature from 5.8 to 19.0 °C, while the average relative humidity and total rainfall was 66% and 16.6 mm, respectively during the crop period. The soil of the experimental site was well-drained loamy sand. The initial soil pH was 8.08 with electrical conductivity 0.40 dSm^{-1} and an organic carbon content of 3.60 g kg^{-1} while the available N, P and K contents were 116.4, 24.2 and 164.0 kg $ha^{"1}$, respectively and DTPA extractable Zn, Fe. Mn and Cu were 0.55, 4.38, 2.14 and 0.23 ppm. The experiment was laid out in a randomized block design with 10 treatments. Each treatment was replicated 3 times.

Treatments:

T_1: Control (RDF of NPKS)

T_2: RDF+3 sprays of 0.5% Urea Phosphate (17:44:0) (UP)

T_3: RDF +3 sprays of 1.0% Urea Phosphate (17:44:0) (UP)

T_4: RDF +3 sprays of 1.0% Urea Phosphate with SOP (18:18:18) UPSOP

T_5: RDF +3 sprays of 1.0% Sulphate of Potash (0:0:50) SOP

T_6: RDF + 1st spray 0.5% UP, 2nd spray 1.0% UPSOP, 3rd spray of 1.0% SOP

T_7: RDF + 1st spray 1.0%UP, 2nd spray 1.0% UPSOP, 3rd spray of 1.0% SOP

T_8: RDF + 1st spray 0.5%UP, 2nd spray 1.5% UPSOP, 3rd spray of 1.5% SOP

T_9: RDF + 1st spray 1.0%UP, 2nd spray 1.5% UPSOP, 3rd spray of 1.5% SOP

T_{10}: RDF + 1st spray 1.0%UP, 2nd spray 2.0% UPSOP, 3rd spray of 2.0% SOP

Composition of 100% of water soluble fertilizers: Urea phosphate, Sulphate of Potash (SOP) and Urea phosphate with SOP were used for foliar spray in the experiment. Urea phosphate and Urea phosphate with SOP was obtained from Indian Farmers Fertilizer Cooperative Limited (IFFCO) which was manufactured at its Kandla plant (Gujarat, India) whereas Sulphate of Potash (SOP) was imported by IFFCO from other countries. The compositions of these products as per FCO are as follows:

Table 1. Composition of 100% Water soluble fertilizers

Name of Product / grade	Nutrient Concentration (%) N	P	K	S
Urea Phosphate (UP)	17	44	0	0
Sulphate of Potash (SOP)	0	0	50	17.5
Urea Phosphate with SOP	18	18	18	6.1

Field management and treatments application: Field was prepared with 2 cross harrowing followed by planking. Sowing of mustard (var. RH 749) was done on 20.10.2018 with seed rate of 5 kg/ha. Mustard was sown at 10 × 30 cm plant geometry. FYM (5 t/ha) and recommended dose of nitrogen, phosphorus, potash and sulphur (90:40:0:30) was applied equally in all plots. For weed management, hand weeding was done at 25-35 DAS. 100% Water Soluble Fertilizers were applied at different concentrations as per the treatment detail. Water soluble fertilizers were applied at branching (30 DAS) flowering (45 DAS) and silique formation (60 DAS) stages @ 500 litre per hectare by using Knapsack sprayers with flat fan nozzle to obtain fully wet the leaves with fine spray.

Observations: The growth and yield attributes were estimated as per the standard procedure by sampling from 3 places in each plot. From the net plots, after leaving the 2 border rows on either side of the plots, crops were harvested manually with sickle on 10.03.2019. After sun drying of few days, the biological yield was recorded. Straw yield was obtained by subtracting the economical yield from biological yield of individual plots. Harvest Index was calculated as follows:

$$HI\ (\%) = \frac{\text{Grain yield (kg ha}^{-1})}{\text{Biological yield (kg ha}^{-1})} \times 100$$

HI = Harvest Index

Economics and statistical analysis: The net returns of mustard cultivation under various applications of 100% water soluble fertilizers were calculated by subtracting cost of cultivation of individual treatment from gross returns of respective treatments, and finally the benefit: cost ratio was calculated. Cost of cultivation for each treatment was calculated as sum of expenditure incurred on sowing to threshing of crop. For computation of cash inputs, market price of inputs was considered. Gross Monetary Returns (GMR) were estimated by using minimum support price (MSP) announced by Government of India for every year.GMR, NMR and BCR were calculated by following formulas :

$$GMR\ (Rs.\,ha^{-1}) = GY\ (kg\ ha^{-1}) \times MSP\ (Rs\ kg^{-1}) + SY\ (kg\ ha1) \times selling\ price\ (Rs\ kg^{-1})$$

NMR (Rs ha^{-1}) =GMR (Rs ha^{-1}))- COC (Rs ha^{-1})

$$BCR = \frac{GMR\ (Rs\ ha^{-1})}{Cost\ of\ Cultivation\ (Rs\ ha^{-1})}$$

Where,

GMR= Gross Monetory Return;

NMR=Net Monetory Return,

COC= Cost of Cultivation

GY=Grain Yield and

SY=Stover yield (MSP of mustard during 2018-19: Rs. 42 kg^{-1}, Selling price of stover @ Rs. 2 kg^{-1})

BCR=B:C Ratio,

All data were statistically analyzed following ANOVA procedure using the statistical program OPSTAT *(Sheoran et al., 1998)*.

RESULTS AND DISCUSSION

Growth and development characters: Foliar feeding of water soluble fertilizers alongwith recommended dose of fertilizer increased plant height, leaf area index and chlorophyll content of mustard at different intervals (Table 2). Plant height at 60 and 90 DAS was recorded maximum with the application of first spray of 1.0 % UP+ 2nd spray of 2.0 % UPSOP and 3rd spray of 2.0% SOP (T_{10}) followed by first spray of 1.0 % UP+ 2nd spray of 1.5 % UPSOP and 3rd spray of 1.5% SOP (T_9) then first spray of 0.5 % UP + 2nd spray of 1.5 % UPSOP and 3rd spray of 1.5% SOP (T_8). These treatments were found significantly higher over control (RDF) There was no significant increase in plant height at 45 DAS over control. T_7 and T_8 revealed at par results at all the intervals. Application of 3 sprays of 1.0 % UPSOP (T_4) also significantly increased plant height over control at 60 and 90 DAS. This may be due to that considerable quantities of soilapplied nutrients would have become unavailable to the crop as it grew. The ready supply of the required nutrients to the leaves (site of their metabolism) would more than compensate for the 'hidden hunger' of the growing crop for N and P. These results broadly corroborate the findings of *(Siddiqui et al., 2008)*. These nutrients play vital role as a component of many metabolically important compounds *(Marschner, 2002)*which would involve directly or indirectly in cell division, cell enlargement and tissue and organ formation resulting in improvement in values for growth parameters.

Table 2. Effect Foliar application of WSFs on plant growth parameters of mustard

Treatments	Plant height (cm)			Leaf Area Index			Chlorophyll Content (%)		
	45 DAS	60 DAS	90 DAS	45 DAS	60 DAS	90 DAS	45 DAS	60 DAS	90 DAS
T1	63.7	124.3	161.7	2.71	3.51	5.02	35.6	37.6	39.6
T2	64.7	140.3	180.3	2.79	3.61	5.27	37.0	38.9	40.9
T3	65.0	142.3	180.7	2.81	3.67	5.33	37.7	40.1	42.3
T4	64.7	145.0	186.7	2.80	3.67	5.37	37.0	38.7	43.0
T5	64.3	142.3	182.0	2.77	3.64	5.37	36.6	38.5	41.5
T6	64.7	146.0	184.3	2.80	3.62	5.51	36.7	39.0	43.3
T7	64.7	149.3	187.3	2.82	3.68	5.64	37.8	42.5	44.0
T8	64.7	147.0	187.0	2.78	3.72	5.60	37.6	40.8	44.6
T9	65.0	149.3	189.7	2.81	3.83	5.68	37.4	43.1	45.5
T10	64.7	152.0	191.0	2.82	3.95	5.74	37.9	43.4	45.7
C.D.	NS	4.8	6.2	0.06	0.10	0.14	0.8	1.7	1.9
SE(m)		1.59	2.07	0.021	0.033	0.047	0.28	0.56	0.65

Different doses of water soluble fertilizers significantly increased the leaf area index over control at all the intervals. However, the different treatments of water soluble fertilizers were nonsignificant with each other at 45 DAS. Leaf area index was significantly increased with the application of first spray of 1.0% UP+ 2nd spray of 2.0% UPSOP and 3rd spray of 2.0% SOP (T10) over control followed by first spray of 1.0 % UP+ 2nd spray of 1.5% UPSOP and 3rd spray of 1.5% SOP (T_9) then first spray of 0.5% UP + 2nd spray of 1.5% UPSOP and 3rd spray of 1.5% SOP (T_8) at 60 and 90 DAS. Improvement in leaf area index (Tables 2) seems to be mainly responsible for the observe parallel increase in the various yield characteristics studied. The increased leaf area of the treated plants together with efficient carbon assimilation made them enableto produce higher quantities of photosynthates which resulted in the higher dry weight of the treated plants *(Marschner, 2002)*. These sequences of events led to a positive and sustained effect on the yield attributing characters which ultimately resulted in the maximization ofseed yield. This increased growth was due to additional supply of nutrients through foliar application which increased the nutrient uptake and better translocation of nutrients.

Chlorophyll content in leaves of mustard was recorded maximum in treatment T_{10} followed by T_7 at 45 DAS. Maximum chlorophyll at 60 DASwas recorded under treatment T_{10} followed by T_9 then T_7. At 90 DAS, application of first spray of 1.0 % UP+ 2nd spray of 2.0 % UPSOP and 3rd spray of 2.0% SOP (T_{10}) recorded significantly highest chlorophyll content over recommended dose of fertilizers followed by T_9.

Higher plant growth parameters at 45 DAS were recorded with application urea phosphate (17:44:0), whereas more plant growth parameters at 60 DAS were recorded with application urea phosphate with SOP (18:18:18). Higher yield attributing characters and plant growth parameters at 90 DAS were recorded with application of sulphate of potash (0:0:50). Theseresultsindicates that application of urea phosphate in the plant growth period is more beneficial, whereas application of urea phosphate with SOP (18:18:18) before flowering is more beneficial. Application of sulphate of potash (0:0:50) during later stage *i.e.,* silique formation stage is more beneficial. These findings were in accordance with the observations of *Mudalagiriyappa et al., 2016.*

Yield attributing characters and yield : Foliar feeding of water soluble fertilizers alongwith recommended dose of fertilizer increased yield attributing characters and yield (Table 3). Application of different water soluble fertilizers increased the length of siliqua under different treatments. Highest length of siliqua was found with one spray of 1.0 % UP+ 2nd spray of 2.0 % UPSOP and 3rd spray of 2.0% SOP (T_{10}) this was significantly higher over control (T_1). Number of seeds per siliqua were also increased with the foliar feeding of water soluble fertilizers. A significant increase was recorded under treatment T_{10} over control. Total number of siliqua per plant were observed maximum with the one foliar spray of 1.0 % UP+ 2nd spray of 2.0 % UPSOP and 3rd

Table 3. Effect Foliar Application of WSFs on Yield and Yield Attributing Characters of Mustard

Treatments	LS	SS	TS	TW	SY	HI
T1	5.28	17.3	268	4.44	2803	30.8
T2	5.37	19.4	275	4.52	2967	31.3
T3	5.38	19.5	280	4.54	3000	31.6
T4	5.42	19.6	303	4.55	3017	31.7
T5	5.42	19.6	300	4.55	2983	31.6
T6	5.40	19.7	285	4.55	2983	31.4
T7	5.47	19.9	322	4.61	3100	31.9
T8	5.47	20.0	320	4.60	3350	31.8
T9	5.63	20.1	330	4.62	3433	32.1
T10	5.67	20.2	338	4.67	3567	32.3
C.D.	0.10	0.2	23	NS	440	NS
SE(m)	0.03	0.1	8		147	

LS=Length of siliqua (cm); SS=Seeds/ siliqua (No.)
TS=Total siliqua/ plant (No.); TW=Test weight (g)
SY=Seed yield (kg/ha); Harvest Index (%)

Table 4. Effect of Foliar Application of WSFs on Economics of Mustard Cultivation

Treatments	COC	GMR	NMR	BCR
T1	33529	1,30,413	96,884	2.89
T2	36282	1,37,600	1,01,318	2.79
T3	36874	1,39,000	1,02,126	2.77
T4	36912	1,39,667	1,02,755	2.78
T5	36859	1,38,267	1,01,408	2.75
T6	36684	1,38,400	1,01,716	2.77
T7	36882	1,43,533	1,06,651	2.89
T8	37083	1,55,333	1,18,250	3.19
T9	37280	1,58,800	1,21,520	3.26
T10	37679	1,64,800	1,27,121	3.37
C.D.		17,686	17,686	NS
SE(m)		5,906	5,906	

COC=Cost of cultivation (Rs/ha); GMR= Gross monetary return (Rs/ha); NMR=Net monetary return(Rs/ha);
BCR= B:C Ratio,

spray of 2.0% SOP (T_{10}) which was significantly higher than control (T_1). Test weight of mustard seeds was also increased with the foliar application of water soluble fertilizers. Although the increase in the test weight of seeds was found nonsignificant. Similar findings were also reported by *Siddiqui et. al., 2008*.

Seed yield of mustard significantly increased with the application of water soluble fertilizers as one foliar spray of 1.0 % UP+ 2nd spray of 2.0 % UPSOP and 3rd spray of 2.0% SOP (T_{10}) followed by T_9 and T_8 over control. The above propositions are further confirmed by studies wherein seed yield was found to be significantly and positively related to most of the characteristics studied *(Siddiqui, 2005)*.Foliar application of 3 sprays of 1% UP and UPSOP increased seed yield over control. No significant increase was found in harvest index, however, it was increased over control with application of water soluble fertilizers.

The higher yield of mustard seemed to be the cumulative effect of yield attributes which was boosted by application of water soluble fertilizers. These findings clearly indicate that the highest crop response in terms of yield was found with timely application of nutrients through water soluble fertilizers. Similar results were also reported by *Shukla et. al, 2020.*

Economic: Further foliar feeding of water soluble fertilizers showed significant response on the economics of cultivation of mustard crop (Table 4).

The highest Gross Monetary Return, GMR (Rs. 1,64,800/ha), Net Monetary Return, NMR (Rs 1,27,121/ ha) and B:C Ratio (3.37) was recorded with the application of water soluble fertilizers as one foliar spray of 1.0 % UP+ 2nd spray of 2.0 % UPSOP and 3rd spray of 2.0% SOP (T_{10}). GMR and NMR in treatment T_{10} was significantly 26.4% and31.2.3% higher, respectively than in 100% recommended dose of fertilisers (T_1). Although, BCR was also 16.6% higher in T_{10} than in T_1 but not significant. These results were in close proximity with the findings of *Gayathri and Singh, 2021.*

CONCLUSION

On the basis of present study it may be concluded that water soluble fertilizers supplement nutritional needs of the crops in their critical life stages. Being water soluble, these fertilizers are the ideal solution for feeding the necessary amounts of micro and macro nutrients to growing crops. These fertilizers have low salt index, thus reducing the probability of plant tissue burn. This makes water soluble fertilisers suitable for both foliar and fertigation applications. Thus, water soluble fertilizers may be an option to increase the yield of agricultural produce. These are not only convenient to use as they can be simply sprayed on plants but also are cost effective as eliminates the additional cost of buying in bulk which is a major hindrance with traditional fertilizers. The results of the study highlighted that higher yield of mustard and net return can be achieved with the application of recommended dose of fertilizers along

with 3 foliar sprays of water soluble fertilizers *viz:* 1st spray of 1.0 % Urea Phosphate (17:44:0) + 2nd spray of 2.0 % Urea Phosphate with SOP (18:18:18) and 3rd spray of 2.0% SOP (0:0:50) under semi-arid conditions of Rajasthan. Water soluble fertilizers increase the availability of nutrients which helps the plant in its physiological growth and also provides the nutritional requirements of the crop in crucial stages. The awareness about these water soluble fertilizers is becoming more, it may be safe to assume that these fertilizers may surge in the upcoming years and will inspire novel innovations in the farming practices.

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