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Effect of Water Soluble Fertilizers on Yield and Economics of Indian Mustard {*Brassica juncea* (L.)}

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ABSTRACT

A field experiment was conducted during *rabi* season 2019-20 at Agricultural Research Station, Navgaon (Alwar), S.K.N Agriculture University, Jobner, Jaipur (Rajasthan) India, to study the effect of water soluble fertilizer on yield of mustard. The experiment was laid out in a randomized block design with eleven treatments and replicated thrice. The crop was sown as per the package of practices recommended for zone IIIB of Rajasthan. The treatments were application of 50 % RDF (N:P_2O_5:K_2O 40:20:20 kg ha^{-1}), 75 % RDF (N:P_2O_5:K_2O 60:30:30 kg ha^{-1}), 100 % RDF (N:P_2O_5:K_2O 80:40:40 kg ha^{-1}), 50 % RDF + foliar spray of 19:19:19 @ 2% , 75 % RDF + foliar spray of 19:19:19 @ 2%, 50 % RDF + foliar spray of DAP @ 2%, 75 % RDF + foliar spray of DAP @ 2%, 50% RDF + foliar spray of urea @ 2%, 75% RDF + foliar spray of urea @ 2%, including foliar water spray and Control. Among the treatments, application of water soluble fertilizer i.e. 75 % RDF + foliar spray of 19:19:19 @ 2% was recorded significantly higher plant height at 30, 60, 90, 120 DAS and at harvest stage, 23.4 cm, 118.2 cm, 156.6 cm, 197.5 cm, 198.9 cm respectively), siliqua per plant (159), seed per siliqua (14), test weight (4.98 gm), seed yield (3666 kg ha^{-1}), stover yield (9780 kg ha^{-1}), with higher harvest index (27.25%) and gross returns (Rs.162211 ha^{-1}) and net returns (Rs.127804 ha^{-1}). However, benefit cost ratio established its economic superiority over other treatments. However, it remained at par with 50 % RDF (N:P_2O_5:K_2O 40:20:20 kg ha^{-1}), 75 % RDF (N:P_2O_5:K_2O 60:30:30 kg ha^{-1}), 100 % RDF (N:P_2O_5:K_2O 80:40:40 kg ha^{-1}), 50 % RDF + foliar spray of 19:19:19 @ 2% , 50 % RDF + foliar spray of DAP @ 2%, 75 % RDF + foliar spray of DAP @ 2%, 50% RDF + foliar spray of urea @ 2%, 75% RDF + foliar spray of urea @ 2%. However, foliar water spray and control were recorded significantly lowest plant height, siliqua per plant, seed per siliqua, test weight, seed yield, stover yield with higher harvest index (%) and gross returns, net returns and BC ratio.

Keywords *water soluble fertilizer, mustard, foliar spray, yield and BC ratio*

The importance of oilseeds in Indian economy is well documented and there is every need to raise the oilseed production to bridge the large gap between the demand and supply of edible oils. Mustard is most dominated oilseed crop of Rajasthan both in area and production. The India is producing about 9.34 million tons (Anonyms, 2019) of mustard from an area of 6.13 million hectare with an average productivity of 1205 kg ha^{-1} (Anonyms, 2018). Rajasthan, which is one of the major mustard growing state, produces 3.4 million tons of mustard from 2.18 million hectares area with an average productivity of 1558 kg ha^{-1}. Nine annual oilseed crops are grown in India of which, oilseed Brassica, has a great significance due to high oil content, large acreage and diversified uses of oil. Eight species of oilseed Brassica are grown in India mainly for edible oil (Prasad, 2013).To meet the edible oil demand in future, it is necessary to exploit all the conventional and non-conventional resources for edible oilseed production. Indian mustard is an important *rabi* oilseed crop grown under varied agro-climatic conditions. Experimental evidences show that nearly all the elements are absorbed more or less readily by the leaves of various plants. Nutrient elements which are absorbed through roots can be absorbed with equal efficiency through foliage. In many parts of our country micronutrient like zinc, boron, molybdenum and others have been reported to be deficient. Plant nutrients availability at appropriate amount is unavoidable for

obtaining higher yields (Habtegebrial and Singh, 2006). Foliar application of nutrients, especially the expensive major and minor nutrients can be applied to crop plants in the form of a spray where the nutrients readily reach the actual site of activity (Ko³ota and Osiñska, 2000). Water soluble fertilizers are used in sprinkler or drip irrigation systems and for foliar spray to enhance yield and to improve quality of fruits and vegetable crops. 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. These are high analysis fertilizers developed to suit the matrix of status of soil fertility, type of crop, quality of water to be used and climatic conditions. In water soluble fertilizers it is easy to make the precise amount of nutrient solution for plants. Water-soluble fertilizers should meet certain qualities such as 100% soluble and no inert matter, high purity, driven by R&D, nutrients in readily available form, free from sodium and chloride, low salt index, (EC=0.9-1.2), pH acidic (5.5 to 6.5), suitable for fertigation and foliar application, improve crop yields and quality of produce and ultimately higher nutrient use efficiency (Malhotra, 2016). Use of liquid or water soluble fertilizers in India is sparse in comparison to developed countries. In USA during 2009 the consumption of water soluble fertilizers was 17% of the total fertilizers used in all crops (Patel 2011). A number of water soluble fertilizers have been developed and included by GOI in Fertilizers Control Order, 1985 (FAI 2013).Various water soluble grade fertilizers can be used at different growth stages of crops either alone or in combination to improve the crop productivity. The NPK combination are starter grades (19:19:19; 20:20:20; 18:18:18), nitrogen-potash rich grade (13:5:26) for growth in middle stage and mono-potassium phosphate (0:52:34); mono-ammonium phosphate (12:61:0); potassium nitrate (13:0:45) for sugar conversion and disease resistance.

In India, the production and use of conventional fertilizers started in 1906. However, the use of liquid or water soluble fertilizers is new and their use started with growth of micro irrigation system 20 years back. Initially growth was slow and confined to Maharashtra. Presently Rajasthan became first rank in micro irrigation. The country has witnessed good growth in last 20 years as their usage started in modest quantities from 1200 MTs in 1995 to 130000 MTs in 2013-14 (Patel 2011 and Chander 2014). Out of which fertigation has major share of about 84% and balance by foliar. The growth in consumption increased over the years. Total consumption of water soluble fertilizers is still lower than the other countries which are less than 0.25% in comparison to the global average is 5-6%. The India's share of conventional fertilizers is 14% at world level, whereas it is about 1% of water soluble. Maharashtra state was the first to start the use of water soluble fertilizers in 1992, however now their use has spread in other states also (Chander 2014). Application of fertilizers directly to leaves is called foliar feeding or foliar spray. The method is almost invariably used to apply water-soluble straight fertilizers and used especially for high value crops such as fruits (Malhotra, 2016).

Foliar application can be a supplement to soil fertilization at a critical time for the plant, but not a substitute since greater amounts of plant nutrients are needed than what can be absorbed through the plant leaf at any given time. A nutrient spray to the foliage will provide the needed nutrients immediately, allowing the plants to begin growth. Under certain conditions, foliar application is considered better than conventional soil application (Fernandez and Ebert 2005 and Srivastava and Singh 2003b) like; acute shortage of nutrient supply, nutrient imbalances, nutrient either absent or immobilized and nutrient imbalances. Foliar fertilizer application may results in better nutrients absorption by the plants and thus can be used for increasing fertilizer use efficiency. Keeping the above aspects in view, the present investigation "Effect of water soluble fertilizer on yield of Indian mustard {*Brassica juncea* (L.)}" has been planned.

MATERIALS AND METHODS

A field experiment was conducted during *rabi* season 2019-20 at Agricultural Research Station, Navgaon (Alwar), S.K.N Agriculture University,

Jobner, Jaipur (Rajasthan) India, to study the effect of water soluble fertilizer on yield of crop mustard. The soil of experimental field was sandy loam in texture. The soil of experimental field was low in organic carbon, low in available nitrogen, and medium in phosphorus and medium in potassium with high in pH. The experiment was laid out in a randomized block design with eleven treatments and replicated thrice. The treatments were application of 50 % RDF ($N:P_2O_5:K_2O$ 40:20:20 kg ha^{-1}), 75 % RDF ($N:P_2O_5:K_2O$ 60:30:30 kg ha^{-1}), 100 % RDF ($N:P_2O_5:K_2O$ 80:40:40 kg ha^{-1}), 50 % RDF + foliar spray of 19:19:19 @ 2% , 75 % RDF + foliar spray of 19:19:19 @ 2%, 50 % RDF + foliar spray of DAP @ 2%, 75 % RDF + foliar spray of DAP @ 2%, 50% RDF + foliar spray of urea @ 2%, 75% RDF + foliar spray of urea @ 2%, including foliar water spray and Control. The crops were sown as per the package of practices recommended for zone IIIB of Rajasthan. The Mustard variety DRMRIJ-31 was sown at the end of the October with seed drill. The seeds were treated with fungicide and sown @ 4-5 kg ha^{-1} at 30 cm x 15 cm spacing at a depth of 5 cm below the soil surface. Foliar spray was done with Knapsack sprayer using Flat Fan nozzle with 600 Littre of water ha^{-1}at flowering stage. Plant height (cm), siliqua per plant, seed per siliqua, test weight (gm) and yield (kg ha^{-1}) were measured manually. Harvest index was calculated by dividing the grain yield (economic yield) by the total dry matter (biological yield) and multiplied by 100, Donald (1962).

$$\text{Harvest index}(\%) = \frac{\text{Economic yield}}{\text{Biological yield}} \text{x} 100$$

The expenditure incurred on individual treatment was worked out from the detail assessment of the fixed and variable costs involved such as land preparation, seed, plant protection, chemicals and labour engaged in different operations. Gross income for all treatment was calculated separately taking into consideration grain and stover yield of individual treatment. Thereafter, net returns were calculated after subtracting expenditure incurred on the individual treatment from the gross expenditure of the same treatment.

The benefit: cost ratio was calculated as follows.

$$\text{B:C} = \frac{\text{Gross return}(\text{Rs.ha}^{-1})}{\text{Cost of cultivation } (\text{Rs.ha}^{-1})}$$

The data presented in this paper are the mean values of different measurements. The statistical method described by Panse and Sukhatme (1961) was followed for statistical analysis and interpretation of the experimental results. In order to evaluate the comparative performance of the various treatments, the data were analysed by the technique of analysis of variance described by Fisher (1950). All the tests of significance were made at 5 % level of significance. To judge the significance of difference between two treatments, critical difference (CD) was worked out by the following formula:

$$\text{CD} = \sqrt{\frac{2 \text{ x Error variance}}{\text{n}}} \text{ x t value at error of d.f.}$$

Where,

n = number of observation averaged

t = Value from Fisher's and Yates's table (1950) for error degree of freedom at 5 % level of significance

CD = Critical difference

RESULTS AND DISCUSSION

Plant height

Plant height was significantly affected by various treatments (Table 1). The data of plant height recorded at 30, 60, 90, 120 DAS and at harvest stage. At 30, 60, 90, 120 DAS and at harvest stage, maximum plant height was recorded under 75 % RDF + foliar spray of 19:19:19 @ 2% (23.4 cm, 118.2 cm, 156.6 cm, 197.5 cm, 198.9 cm respectively) but it was found statistically at par with treatments 50 % RDF ($N:P_2O_5:K_2O$ 40:20:20 kg ha^{-1}), 75 % RDF ($N:P_2O_5:K_2O$ 60:30:30 kg ha^{-1}),100 % RDF ($N:P_2O_5:K_2O$ 80:40:40 kg ha^{-1}), 50 % RDF + foliar spray of 19:19:19 @ 2% , 50 % RDF + foliar spray of DAP @ 2%, 75 % RDF +

Table 1: Effect of water soluble fertilizer on Plant height (cm) in mustard crop

Treatments	30 DAS	60 DAS	90 DAS	120 DAS	At Harvest
50 % RDF (N:P_2O_5:K_2O 40:20:20 kg ha^{-1})	19.5	113.8	143.8	189.9	190.1
75 % RDF (N:P_2O_5:K_2O 60:30:30 kg ha^{-1})	20.1	113.9	148.2	190.3	191.2
100 % RDF (N:P_2O_5:K_2O 80:40:40 kg ha^{-1})	21.9	116.0	153.3	194.7	195.3
50 % RDF + Foliar spray of 19:19:19 @ 2%	22.8	116.0	153.5	194.7	195.9
75 % RDF + Foliar spray of 19:19:19 @ 2%	23.4	118.2	156.6	197.5	198.9
50 % RDF + Foliar spray of DAP @ 2%	21.2	115.2	152.8	194.4	196.7
75 % RDF + Foliar spray of DAP @ 2%	21.4	117.3	154.2	196.2	197.9
50% RDF + Foliar spray of urea @ 2%	21.5	116.2	153.7	194.6	196.0
75% RDF + Foliar spray of urea @ 2%	21.6	117.5	154.2	197.0	198.3
Foliar water spray	17.1	109.7	139.9	180.0	183.8
Control	16.7	108.1	136.4	178.1	182.6
SEm ±	1.6	2.8	5.5	5.7	5.7
CD at 5%	4.8	8.2	16.1	16.8	16.8

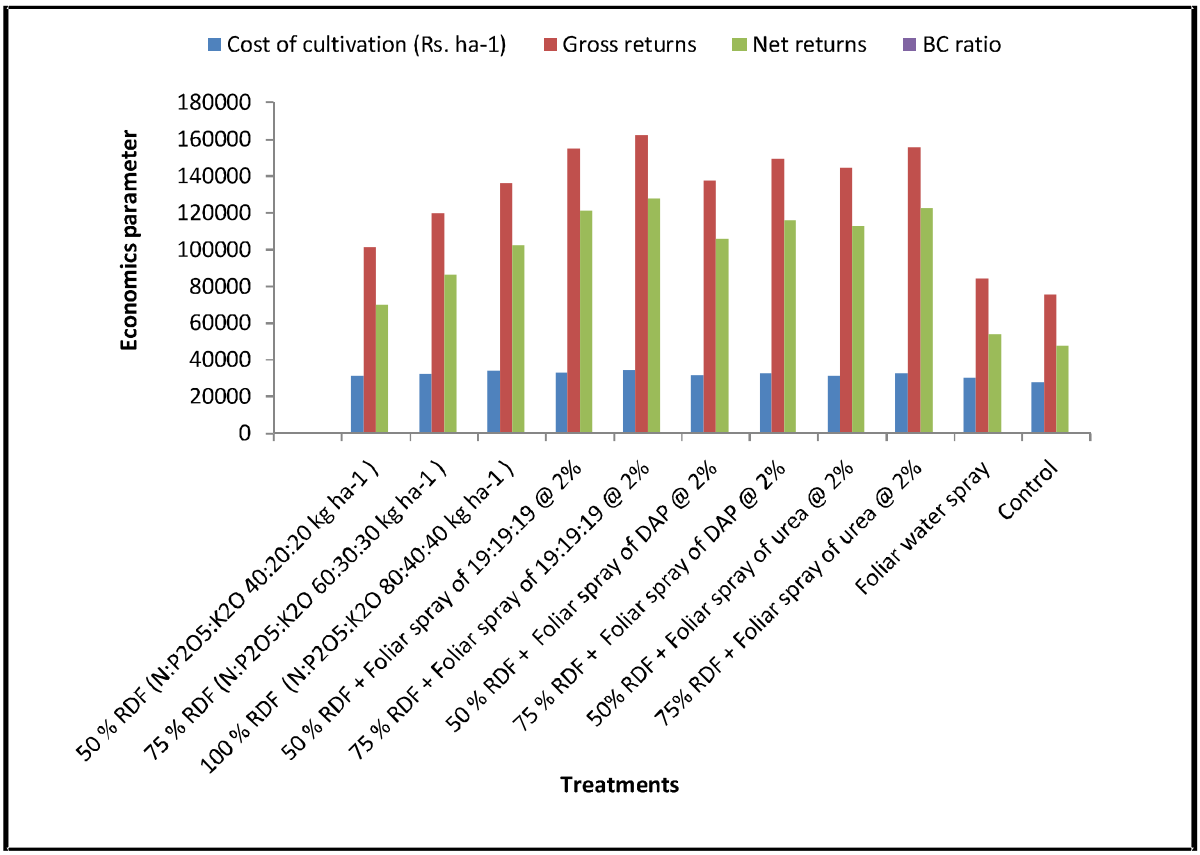

Fig. 1: Effect of water soluble fertilizer on economics in mustard crop

Table 2: Effect of water soluble fertilizer on yield attributes and yields in mustard crop

Treatments	Siliqua/plant (No.)	Grains/ Siliqua (No.)	1000 grain wt.(g)	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)
50 % RDF (N:P_2O_5:K_2O 40:20:20 kg ha^{-1})	143.00	11.67	4.13	2288	8468	21.21
75 % RDF (N:P_2O_5:K_2O 60:30:30 kg ha^{-1})	152.67	12.33	4.27	2701	9060	22.96
100% RDF (N:P_2O_5:K_2O 80:40:40 kgha^{-1})	153.33	13.33	4.53	3077	9618	24.26
50 % RDF + Foliar spray of 19:19:19 @2%	155.00	13.67	4.97	3497	9611	26.65
75 % RDF + Foliar spray of 19:19:19 @2%	158.67	14.00	4.98	3666	9780	27.25
50 % RDF + Foliar spray of DAP @ 2%	154.00	13.00	4.70	3106	9031	25.63
75 % RDF + Foliar spray of DAP @ 2%	156.33	13.67	4.74	3367	9429	26.33
50% RDF + Foliar spray of urea @ 2%	154.67	13.33	4.68	3263	9053	26.25
75% RDF + Foliar spray of urea @ 2%	155.67	14.00	4.80	3513	9674	26.41
Foliar water spray	134.33	10.67	3.97	1899	6942	21.41
Control	125.33	10.33	3.96	1709	6483	20.81
SEm ±	4.36	0.96	0.16	252.10	309.96	1.57
CD at 5%	12.78	2.82	0.48	739.44	909.15	4.61

foliar spray of DAP @ 2%, 50% RDF + foliar spray of urea @ 2%, 75% RDF + foliar spray of urea @ 2%. Minimum was recorded under treatment (control). It might be due to foliar spray increase absorption of nutrient solution which might have accelerated photosynthetic rate, thereby increasing the supply of carbohydrates, resulted in increased cell division and elongation leading to increased plant height. Toscano *et al*. 2002 also found that foliar-applied nutrients are rapidly absorbed and used by the plant. Absorption begins within minutes after application and, with most nutrients; it is completed within 1 to 2 days.

Foliar fertilizer applications are a alternative to provide nutrients to plants when soil conditions may limit the root uptake or during fast growth periods when needs may exceed root supply.

Yield attributes and yield

In the present investigation, various treatments favorably influenced the yield parameter of mustard siliqua per plant, seed per siliqua, test weight (Table 2). The treatment 75 % RDF + foliar spray of 19:19:19 @ 2% produced maximum number of siliqua per plant (159) and seed per Siliqua (14), which were significantly higher than other treatment. Test weight (4.98 gm) also found significantly higher in above treatment. Significantly highest harvest index (27.25%) was recorded in 75 % RDF + foliar spray of 19:19:19 @ 2% treatment. Stover yield indicated vegetative growth which in term influences the seed yield to an enormous extent. Significantly higher stover yield was recorded in 75 % RDF + foliar spray of 19:19:19 @ 2% treatment (9780 kg ha^{-1}). Seed yield is an important parameter which decides the efficiency and superiority of a particular treatment over other treatments. Application of treatment water soluble fertilizer i.e. 75 % RDF + foliar spray of 19:19:19 @ 2%, were recorded significantly higher seed yield (3666 kg ha^{-1}), over other treatments, however these were at par with treatments 100 % RDF (N:P_2O_5:K_2O 80:40:40 kg ha^{-1}), 50 % RDF + foliar spray of 19:19:19 @ 2% , 50 % RDF + foliar spray of DAP @ 2%, 75 % RDF + foliar spray of DAP @

Table 3. Effect of water soluble fertilizer on economics in mustard crop

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	BC ratio
50 % RDF (N:P2O5:K2O 40:20:20 kg ha^{-1})	31475	101249	69774	3.22
75 % RDF (N:P2O5:K2O 60:30:30 kg ha^{-1})	32757	119532	86775	3.65
100 % RDF (N:P2O5:K2O 80:40:40 kg ha^{-1})	34039	136153	102114	4.00
50 % RDF + Foliar spray of 19:19:19 @ 2%	33125	154731	121606	4.67
75 % RDF + Foliar spray of 19:19:19 @ 2%	34407	162211	127804	4.71
50 % RDF + Foliar spray of DAP @ 2%	31715	137426	105711	4.33
75 % RDF + Foliar spray of DAP @ 2%	32997	149008	116011	4.52
50% RDF + Foliar spray of urea @ 2%	31534	144383	112849	4.58
75% RDF + Foliar spray of urea @ 2%	32816	155431	122614	4.74
Foliar water spray	30124	84029	53905	2.79
Control	28059	75632	47573	2.70

2%, 50% RDF + foliar spray of urea @ 2%, 75% RDF + foliar spray of urea @ 2%. While lowest (1709 kg ha^{-1}) was recorded treatment without application of any treatment (control). It might be due to foliar spray of which increase nutrient uptake, which might be enhance photosynthetic rate, thereby increasing the supply of carbohydrates, resulted in increased cell division, multiplication and elongation leading to increased siliqua per plant, seed per siliqua, test weight, seed yield, stover yield. Foliar application of fertilizers in many crops has been reported effective with respect to growth, yield, quality and shelf life. (Dutta *et al*. 2000, Govind and Singh 2003, Peyvasi *et al*. 2009). Kumar *et al.* (2013) also reported that the foliar application of soluble starter NPK @ 2 per cent + sulphur spray 2 per cent at 45 DAS and soluble booster NPK 2 per cent + boron spray 0.15 per cent at 65 DAS resulted in significantly higher oil content, oil yield, protein content. Similarly, Vinothkumar *et al.* (2013) also revealed that foliar spray of 2 per cent DAP twice at flower initiation and pod formation stages of crop resulted significantly higher grain yield (1460 kg ha^{-1}) and it was at par with 2 per cent urea phosphate and TNAU pulse wonder spray.

Economics

The data pertaining to cost of cultivation are presented in Fig.1. The data indicate that the lowest cost of cultivation was recorded in control treatment (Rs. 28059 ha^{-1}) due to no any application use of fertilizer, whereas, it was higher with 75 % RDF + foliar spray of 19:19:19 @ 2% treatment (Rs.31475 ha^{-1}). The treatment 75 % RDF + Foliar spray of 19:19:19 @ 2% recorded higher gross returns (Rs.162211 ha^{-1}) and net returns (Rs.127804 ha^{-1}) as compared to rest of treatments. A variation in net returns was also observed due to application of fertilizers. Highest BC ratio was recorded in 75% RDF + Foliar spray of urea @ 2% treatment (4.74) which was at par with 75 % RDF + foliar spray of 19:19:19 @ 2% treatment. It might be due to difference in dose or level of fertilizer and seed yield. Similar results also observed by Sharifi *et al.*, 2018 and Vinothkumar *et al.* (2013) the benefit cost ratio was higher in the treatment foliar application of RDF + foliar application of WSF @ 2 % at flowering + pod filling stage. Kumar *et al.* (2013) also reported that foliar spray of 2 % of DAP twice at flowering initiation and pod formation

stage of crop growth resulted in significantly higher net return of Rs 20,090 with B: C Ratio of 2.22 in soybean. Therefore it was concluded from the experiment that the application of water soluble fertilizer is promising way for obtaining higher yield and net returns of mustard crop in zone IIIB of Rajasthan.

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