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Ardith Sankar
Department of Agronomy, Institute of Agricultural Sciences Banaras Hindu University, Varanasi, Uttar Pradesh, India

Avijit Sen
Department of Agronomy, Institute of Agricultural Sciences Banaras Hindu University, Varanasi, Uttar Pradesh, India

Rajendra Prasad Singh
Department of Agronomy, Institute of Agricultural Sciences Banaras Hindu University, Varanasi, Uttar Pradesh, India

Correspondence
Ardith Sankar
Department of Agronomy, Institute of Agricultural Sciences Banaras Hindu University, Varanasi, Uttar Pradesh, India

Effect of nutrient management on the yield and yield attributes of rainfed mustard (*Brassica juncea* L. Czern. and Coss.)

Ardith Sankar, Avijit Sen and Rajendra Prasad Singh

Abstract
A field experiment was conducted at the Agricultural Research Farm of Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during the *rabi* season of 2013-14 to study the effect of nutrient management on the yield and yield attributing characters of rainfed mustard (*Brassica juncea* L.). The experiment consisted of ten different treatment combinations of basal dose of fertilizers and foliar spray of 2% urea and 2% Multiplex. The study revealed that among various treatments the application of 100% recommended dose of fertilizer (40 kg N, 20 kg P_2O_5, 20 kg K_2O and 20 kg S ha^{-1}) along with foliar spray of 2% urea +Multiplex was most effective in producing higher yield (765 kg ha^{-1}) and this was followed by 100% RDF + 2% Multiplex foliar spray alone (739 kg ha^{-1}). Seed yield exhibited a significant positive correlation with siliqua $plant^{-1}$ (r = 0.933**), siliqua length (r = 0.902**), seeds siliqua $^{-1}$ (r = 0.717*) and 1000 seed weight (r = 0.901**). The regression analysis between siliqua / plant and seed yield was found to be linear in nature with an R^2 value of 0.871 meaning 87.1% total variation in yield could be explained by the linear function of siliqua $plant^{-1}$. Thus, 100% recommended dose of fertilizer (40 kg N, 20 kg P_2O_5, 20 kg K_2O and 20 kg S ha^{-1}) along with foliar spray of 2% urea +2% Multiplex can be recommended to farmers for growing mustard in rainfed areas of eastern Uttar Pradesh.

Keywords: foliar spray, multiplex, mustard, rainfed, urea

Introduction
Globally, India accounts for 28.3% and 19.8% of the total acreage and production of rapeseed-mustard [22]. In India rapeseed-mustard is grown on an area of 5.76 Mha with production and productivity of 6.82 MT and 1184 kg/ha, respectively [2]. The per capita consumption of edible oils at present is 13.4 kg/annum which would increase to 23.1 kg/annum by 2030 due to improvement in standard of living. In account of the current contribution of rapeseed-mustard (20-25%) to the oilseed production in India about 16.4-20.5 MT rapeseed-mustard needs to be produced to make our country self sufficient in the edible oil sector [6]. Indian mustard (*Brassica juncea* L. Czern. and Coss.) is an important oilseed crop widely grown under rainfed conditions of eastern Uttar Pradesh. It is a winter (*Rabi*) season crop and requires relatively cool temperature, a fair supply of soil moisture during the growing season and a dry harvest period [1]. Mustard oil - considered to be an important constituent of the Indian diet is used as a cooking medium especially in northern parts of India.
In rainfed areas due to insufficient and irregular distribution of rainfall, the crop suffers from moisture stress during various stages of its growth causing insufficient uptake of essential nutrients and impaired physiological processes which ultimately result in decreased yield [12]. It is well known that each essential nutrient has got a definite role to play in the plant metabolism. Enhancing production and productivity of mustard is important to meet its demand in eastern Uttar Pradesh. It is also important to develop low input technology for increasing mustard production under rainfed condition. Major area in our country is under rainfed dryland conditions where mustard is widely grown and consequently suffers from lack of soil moisture during critical growth stages leading to poor growth and yield. It can be grown successfully on residual moisture because of its deep root system [17]. In spite of poor growth under rainfed condition, its yield is not very low but quite unstable due to initial poor stand caused by deficient soil moisture from erratic rainfall.
There is a great scope for increasing productivity of mustard by applying balanced fertilization and maintaining soil fertility status. Due to limited moisture in the root zone, the basal dose of fertilizers is not very effective and under such circumstances foliar feeding - a technique of feeding plants by spraying liquid fertilizer directly to the leaves becomes more effective [8].

Foliar uptake of urea and other nutrients are less dependent on soil conditions and more helpful for dryland conditions, under which urea is absorbed directly and efficiently by the leaves of crop plants [9, 18]. Foliar supply of nutrients has been found to increase the photosynthetic efficiency by delaying the onset of senescence of leaves [19].

Application of macronutrients through basal application and micronutrients (Multiplex) through foliar spray can influence some of the physiological processes [7] which in-turn help minimize the yield reduction due to drought i.e., insufficient soil moisture. Keeping these in view the present investigation was undertaken to enhance the productivity of rainfed mustard by mitigating the effects of dry spells through balanced recommendation of basal dose of fertilizers and foliar spray of nutrients

Materials and Methods

A field experiment was conducted during the *rabi* season of 2013-14 under rainfed condition at the Agricultural Research Farm of Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. The textural class of the experimental site was sandy clay loam which was slightly alkaline (pH= 7.3) in reaction, low in organic carbon (0.35%), available nitrogen (190.50 kg ha-1) and available phosphorus (19.30 kg/ha) and medium in available potassium (210.15 kg/ha) content. Considering the nature of factors under study the experiment consisting of ten treatments (Table 1) was laid out in a Randomized Complete Block Design (RCBD) with three replications. Each replication was divided into ten equal plots and the treatments were randomly allocated to them.

Table 1: Details of treatments.

	Treatment details
T_1	Control
T_2	Water Spray
T_3	2% urea spray
T_4	100% RDF
T_5	50% RDF + 2% urea spray
T_6	50% RDF + 2% Multiplex spray
T_7	50% RDF + 2% urea + 2% Multiplex spray
T_8	100% RDF +2% urea spray
T_9	100% RDF + 2% Multiplex spray
T_{10}	100% RDF + 2% urea +2% Multiplex spray

The mustard variety T-59 (Varuna) was sown on 10th November using a seed rate of 4 kg ha^{-1} at a row spacing of 45 cm. The recommended dose of fertilizer (40 kg N, 20 kg P_2O_5, 20 kg K_2O and 20 kg S ha^{-1}) was applied uniformly to all the plots at the time of sowing below the seed in the form of urea, DAP, muriate of potash. The treatments were applied on 31st December 2013 according to the layout. The crop was harvested on 13th March, 2014.

Results and Discussion

Number of siliqua per plant is one of the yield attributing characters in mustard crop. It was evident from the data (Table 2) that the maximum number of siliqua $plant^{-1}$ was recorded with the application of 100% RDF, 2% urea spray, 2% Multiplex (T_{10}) followed by 50% RDF, 2% Multiplex spray(T_6), 100% RDF, 2% Multiplex spray(T_9). T_{10} was significantly superior to rest of the treatments. Multiplex spray had a positive effect on the number of siliqua $plant^{-1}$. Similar results were obtained by Shinde and co-workers [23], where they found that foliar application of micronutrients produced higher pods per plant in chickpea.

Screening of the data further indicated that the length of siliqua varied significantly with foliar spray of nutrients. Maximum siliqua length was observed with the combined foliar application of 2% urea + Multiplex and soil applied 100% RDF at sowing (T_{10}). This treatment was closely followed by combined application of 100% RDF and foliar applied 2% Multiplex (T_8). However, T_{10} was significantly superior to all other treatments. The result of this investigation was in conformity with the findings of Singh [20] in green gram. However Deka and Shadique [5] reported enhancement of pod length in french bean due to application of boron, molybdenum and zinc.

Table 2: Effect of treatments on the yield and yield attributing characters of mustard.

	Siliqua $plant^{-1}$	**Siliqua length (cm)**	**Seeds $siliqua^{-1}$**	**1000 seed weight (g)**	**Seed Yield (kg ha^{-1})**	**Stover yield (kg ha^{-1})**	**Harvest Index (%)**
Control (T_1)	80.30	4.12	9.44	4.29	453	1741	20.70
Water Spray (T_2)	83.70	4.20	9.46	4.31	456	2053	18.10
2% urea spray (T_3)	84.40	4.50	10.10	4.65	473	2149	20.90
100% RDF (T_4)	121.70	4.55	10.25	5.00	525	2229	22.80
50% RDF + 2% urea spray (T_5)	134.50	4.46	10.00	5.00	585	2731	21.10
50% RDF + 2% Multiplex spray (T_6)	148.20	4.40	9.50	4.75	632	2673	22.80
50% RDF + 2% urea + 2% Multiplex spray(T_7)	143.20	4.53	10.20	5.10	658	3171	20.80
100% RDF +2% urea spray (T_8)	143.70	5.00	10.10	5.21	733	3814	19.60
100 % RDF + 2% Multiplex spray (T_9)	148.00	5.20	11.15	5.35	739	3248	22.20
100% RDF + 2% urea +2% Multiplex spray (T_{10})	176.70	5.40	11.70	5.40	765	3774	20.50
CD (P=0.05)	24.74	0.14	9.44	0.13	188	3.27	NS

The maximum number of seeds $siliqua^{-1}$ (11.70) was observed with the application of 100% RDF as basal and foliar application of 2% urea + 2% Multiplex (T_{10}). It was followed by combined application of 100% RDF and 2% Multiplex (T_9), 100% RDF (T_4), 50% RDF + 2% urea + Multiplex (T_7) respectively. T_3 and T_8 produced equal mean number of seeds $siliqua^{-1}$. Positive effect of application of micronutrients viz. molybdenum, boron and zinc in increasing the number of

seeds per pod was also reported in green gram [20] and radish [14]. The micronutrients might have an enhancing role in seed setting that resulted in higher number of seeds per pod.

The maximum test weight (1000 seed weight) was recorded in treatments with the application of 100% RDF, 2% urea spray, 2% Multiplex(T_{10}) followed by 100% RDF, 2% Multiplex spray(T_9) which were statistically at par with each other. Masuthi *et al.* [13] concluded from their study on cowpea that increase in hundred seed weight might be due to role of micronutrients (boron) in pollen germination, seed development, cell division, translocation of sugar and starch from source to sink.

Highest yield was observed with the application of 100% RDF + 2% urea + 2% Multiplex (T_{10}) which was statistically at par with combined application of 100% RDF + 2% Multiplex spray(T_9) and 100% RDF + 2% urea spray(T_8). It clearly indicated that foliar spray with Fe, Mn and Zn either alone or in combination with urea could give higher seed yield per plant as compared to control. Studies conducted by Tanaka and Fujiwar [24] confirmed the results of the present study. Role of micronutrients in utilization of phosphorus and nitrogen in seed formation and seed setting through translocation of metabolites from source to sink might be the reason for higher seed yield.

Maximum stover yield of 3810 kg ha^{-1} was recorded with the combined foliar application of 100% RDF +2% urea spray (T_8) and minimum with control (1740 kg ha^{-1}). Khan and Qassem [10] and Dadheech *et al.* [3] assessed that foliar spray led to superior seed and stover yield of mustard.

Application of Multiplex (S+Mg+Ca+Fe+Mn+Zn+Cu+B+Mo) through foliar spray has been found to be effective in obtaining better yield in the present study. Kumari [11] found that multiplex applied through foliar application improved the quality of fruit and seed setting in tomato. Of the several micronutrients in Multiplex, zinc and iron are important constituents for many physiological reactions in plants [25]. Severe inadequacy of iron has been found to be detrimental to cell division and therefore reduces growth of leaves [15]. The enzyme carbonic anhydrase, activated by zinc, raises CO_2 volume in chloroplast and increases carboxylation rate of the enzyme RuBisCO where CO_2 is converted into organic carbon sugars through photosynthesis.

Table 3: Correlation coefficient between yield and yield attributes.

	Siliqua plant^{-1}	Siliqua length	Seeds siliqua^{-1}	1000 seed weight	Seed yield	Stover Yield
Siliqua length	0.801**					
Seeds siliqua^{-1}	0.678*	0.924**				
1000 seed weight	0.885**	0.921**	0.828**			
Seed yield	0.933**	0.902**	0.717*	0.901**		
Stover Yield	0.878**	0.898**	0.685*	0.882**	0.964**	
Harvest Index	0.342	0.114	0.181	0.323	0.180	-0.019

*Correlation is significant at 0.05 level (Two-tailed), **Correlation is significant at 0.01 level (Two-tailed).

It is evident from Table 3 that seed yield exhibited a significant positive correlation with siliqua plant^{-1} (r = 0.933**), siliqua length (r = 0.902**), seeds siliqua $^{-1}$ (r = 0.717*) and 1000 seed weight (r = 0.901**). As expected harvest index showed a negative correlation with stover yield. Among the various yield attributes, positive correlation between the number of siliqua and seed weight per plant with seed yield of mustard were also reported by Singh *et al.* [21], Dawson *et al.* [4] and Mohiuddin *et al.* [16].

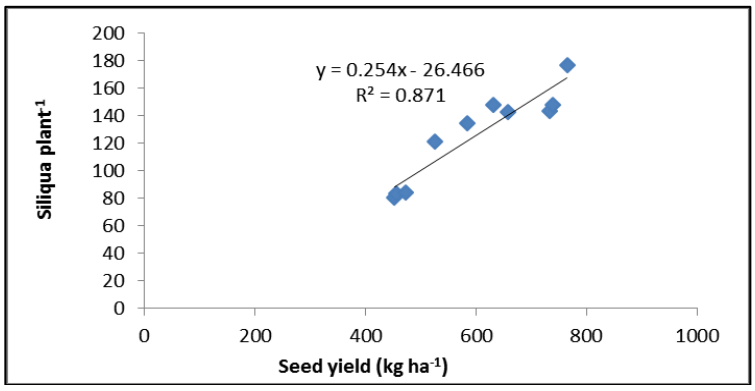

Fig 1: Regression line between siliqua plant $^{-1}$ and grain yield.

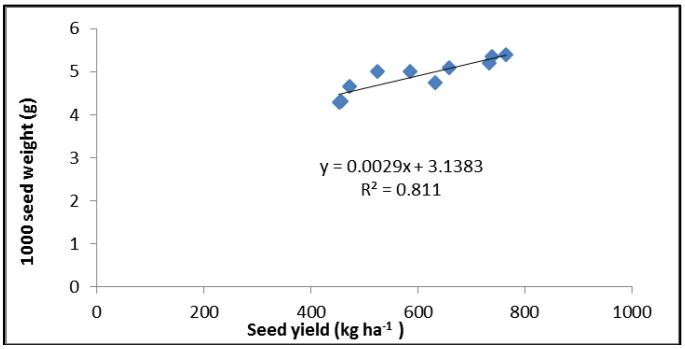

Fig 2: Regression line between 1000 seed weight and grain yield.

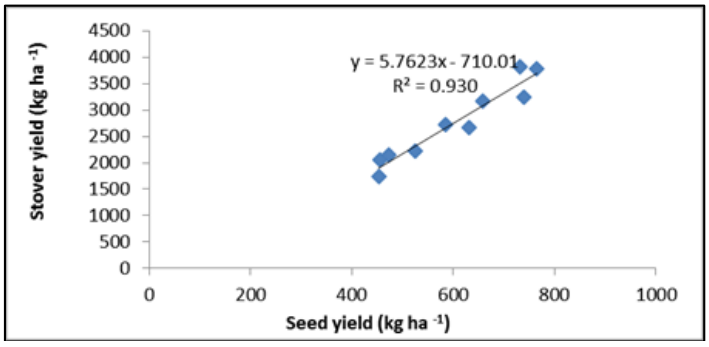

Fig 3: Regression line between seed yield and stover yield

The regression studies revealed that siliqua plant^{-1}, 1000 seed weight and stover yield with seed yield were all linear in nature (Fig 1 to 3).

Conclusion

It can be concluded that in order to achieve higher yield of rainfed mustard, application of 100% recommended dose of fertilizer (40 kg N, 20 kg P_2O_5, 20 kg K_2O and 20 kg S ha^{-1}) along with foliar spray of 2% urea + Multiplex should be applied.

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