Crossref

IJBSM November 2023, 14(11):1550-1555 Print ISSN 0976-3988 Online ISSN 0976-4038

Article AR4920

Research Article Natural Resource Management

DOI: HTTPS://DOI.ORG/10.23910/1.2023.4920

Varietal Performances and Foliar Application of Nutrients on Yield and Economics of Utera Rapeseed-Mustard in Rice-Fallow of Alluvial Soils

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ABSTRACT

A field experiment was conducted during winter seasons (November to February) of 2020–21 and 2021–22 to evaluate performances of different rapeseed-mustard varieties under foliar spray of nutrients on growth, yield components, yield and economics of *utera* (relay) rapeseed-mustard grown in rice–fallow. The experiment was laid out in a split plot design keeping rapeseed-mustard varieties, viz., Anushka, Binoy and PM-28 in main plots and eight different foliar spray of nutrients in sub-plots. Variety PM 28 registered significantly higher growth attributes, yield components, seed yield (1198.5 kg ha^{-1}), stover yield (3300.4 kg ha^{-1}) and biological yield (4498.8 kg ha^{-1}) and also achieved significantly higher return per rupee invested (₹ 2.05) over other two varieties. Foliar spray of N:P:K (19:19:19) @ 2% twice at 30 DAS and 45 DAS+$ZnSO_4$ @ 0.05% at 40 DAS+Boron (20%) @ 0.1% at 50 DAS was found significantly superior to all other foliar sprays with respect to yield components and seed yield (1233.2 kg ha^{-1}), stover yield (3109.9 kg ha^{-1}) and biological yield (4343.2 kg ha^{-1}) irrespective of the varieties and also gave significantly higher return per rupee invested (₹ 1.93) over other foliar application. The study revealed that, cultivation of rapeseed-mustard along with foliar application of nutrients in rice fallow of alluvial soils of West Bengal was a better option to enhance growth, productivity and economics of *utera* rapeseed-mustard.

KEYWORDS: Economics, foliar spray, rice-fallow, rapeseed-mustard, utera crop

Citation* (VANCOUVER)*: Saha et al., Varietal Performances and Foliar Application of Nutrients on Yield and Economics of *Utera* Rapeseed-Mustard in Rice-Fallow of Alluvial Soils. *International Journal of Bio-resource and Stress Management,* 2023; 14(11), 1550-1555. HTTPS://DOI.ORG/10.23910/1.2023.4920.

Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

Conflict of interests: The authors have declared that no conflict of interest exists.

RECEIVED on 24th September 2023 RECEIVED in revised form on 02nd November 2023 ACCEPTED in final form on 16th November 2023 PUBLISHED on 27th November 2023

1. INTRODUCTION

India plays a pivotal role as a producer, importer and exporter in the global edible oil economy. In India rapeseed-mustard is second most important edible oil seed crop contributing about 31 % of the total oilseed produced in our country just after soybean. It is the major oil yielding crop in West Bengal with 0.76 mt of production from 0.61 mha of land area having average productivity (1250 kg ha^{-1}) is much lower than the national average of 1458 kg ha^{-1} (Anonymous, 2022).

In West Bengal, it is grown throughout the state as a cold season crop (*rabi*) under irrigated or restricted irrigated condition (Ray et al., 2015) as sole crop or as mixed crop. The crop rapeseed-mustard (*Brassica* sp.) belongs to the family Cruciferae, having variety of distinctly different plant type, duration, growth characteristics and yield potential are grown for edible oil purpose. In the predominant rice based cropping system, practicing with high yielding long duration rice varieties either rice fallow or delayed sowing of succeeding crops is an obvious, resulting poor crop yield (Mishra and Singh, 2011; Singh, 2014). For the winter crop like rapeseed-mustard, time of sowing plays a crucial role to mine the full genetic potential of a variety as it is a thermo sensitive and photo sensitive crop (Ghosh and Chatterjee, 1988, Mondal et al., 1999). One month delay in sowing can decrease seed yield from about 10 to 50% in different cultivars (Shargi et al., 2011). So sowing time is an important agronomic manipulation for influencing crop growth and yield (Bana et al., 2022). Various critical phenological stages of crop could easily be scheduled during the favourable environment by selecting the appropriate sowing time (Bharat et al., 2022) and method of sowing.

Broadcasting or sowing of rapeseed-mustard after land preparation in rice fallows was found uneconomic due to severe infestation of pest and prevalence of high temperature at the later stage of growth (Samui, 2004). This can easily be overcome by following *utera* system as there is no need of land preparation and basal fertilizer application (Bhowmick et al., 2005). To meet the crop demand soil application of nutrients is more common but under certain circumstances, foliar fertilization is more effective and economical (Fageria et al., 2009). Foliar spray has been shown to be more successful in improving yields by delaying senescence and converting late flushes of flower into pods thereby balancing source to sink relationship ultimately enhancing grain yield (Padbhushan and Kumar, 2014, Banerjee et al., 2019, Singh et al., 2021). The fertilizer elements which are absorbed through roots can also be absorbed with equal efficiency through foliage (Ganapathy et al., 2008). Rapeseed-Mustard in general, is very sensitive to micronutrients especially zinc and boron (Rathore et al., 2015). Zinc shows its essentiality in a series of metabolic activities like carbohydrate metabolism, maintenance of cellular membrane integrity, protein synthesis, regulating auxin synthesis and pollen formation (Hafeez et al., 2013; Karmakar et al., 2021). Boron (B) is directly associated with reproductive parts of the plant by increasing flower production and retention, pollen tube elongation and germination, and seed and fruit development and ultimately the crop yield (Nagula et al., 2015). Considering all these, there is an enormous opportunity to increase the total cropping area through strategic research in rice–fallows (Pande et al., 2012; Barik, 2021).

Targeting rice fallows, there is an enormous opportunity to boost our oilseed production bi-directionally. Addressing these issues an experiment was conceived to study the effects of different rapeseed-mustard varieties and different foliar spray of nutrients on crop growth, yield performances and economics of *utera* rapeseed-mustard grown in rice-fallows of alluvial soils.

2. MATERIALS AND METHODS

A field experiment was conducted during winter seasons (November to February) of 2020–21 and 2021–22 at Pulses and Oilseeds Research Station, Berhampore, West Bengal, India with 24°6' N latitude and 88°15' E longitude and average altitude of 41 m above mean sea level. The experiment was laid out in a split plot design keeping rapeseed-mustard varieties, viz., Anushka (V_1), Binoy or B-9 (V_2) and PM-28 (V_3) in main plots and eight different foliar spray of nutrients viz. F_0: No foliar spray, F_1: Foliar spray with N: P: K (19:19:19) @ 2% at 30 DAS and 45 DAS, F_2: Foliar spray with $ZnSO_4$ @ 0.5% at 40 DAS, F_3: Foliar spray with Boron (20%) @ 0.1% at 50 DAS, F_4: Spray 19:19:19 @ 2% at 30 DAS and 45 DAS+$ZnSO_4$ @ 0.5% at 40 DAS, F_5: Spray 19:19:19 @ 2% at 30 DAS and 45 DAS+Boron (20%) @ 0.1% at 50 DAS, F_6: Spray $ZnSO_4$ @ 0.5% at 40 DAS+Boron (20%) @ 0.1% at 50 DAS, F_7: Spray 19:19:19 @ 2% at 30 DAS and 45 DAS+$ZnSO_4$ @ 0.5% at 40 DAS+Boron (20%) @ 0.1% at 50 DAS in sub-plots. Each treatment was replicated thrice in the experimental field having plots of size 5×4 m^2. The weather of the experimental site was under sub-tropical climate having average annual rainfall ranging from 1200 to 1300 mm concentrating during rainy months from June to September. During the crop growth period the mean maximum temperature varied between 21.3°C to 35.4°C, and mean minimum temperature between 10.7°C to 26.5°C. The maximum and minimum relative humidity ranged between 71.4 to 95.4% and 38.6 to 80.1%, respectively. The soil of the experimental site was silty clay loam in texture, neutral in reaction (pH 7.46) and organic carbon, available nitrogen, phosphorous, and potassium were 0.40%, 299 kg ha^{-1}, 45 kg ha^{-1} and 278 kg ha^{-1} respectively.

The seeds of different varieties of rapeseed-mustard were sown in the standing rice field 10 days before harvesting of rice. Nitrogen, phosphorus and potassium were applied in the form of straight fertilizers i.e. urea, single super phosphate and muriate of potash at 50% of the recommended dose (100, 50 and 50 kg ha^{-1}) just five days before sowing of rapeseed-mustard. Foliar application was done according to the treatments. Irrigation to each plot was uniformly applied as life saver. Plant protection measures were taken as and when required although seeds were treated with fungicides irrespective of treatments.

Experimental pool data were analyzed following standard statistical methods as per Gomez and Gomez (1984). Returns per rupee invested was calculated following cost of cultivation, gross and net return on the basis of prevailing market price for the cost of inputs and value of the produce.

3. RESULTS AND DISCUSSION

3.1. Growth attributes

The growth attributes of *utera* rapeseed-mustard (viz. plant height, number of primary branches $plant^{-1}$, LAI and dry matter accumulation) varied significantly among the tested varieties and various foliar spray of nutrients (Table 1). Highest plant height, dry matter accumulation and number of primary branches $plant^{-1}$were recorded at harvest whereas highest LAI was found at 60 DAS irrespective of varieties and foliar spray of nutrients. Among different varieties, PM-28 registered significantly higher growth attributes like plant height (119.3 cm), dry matter accumulation (401.9 g m^{-2}), LAI (2.74) and number of primary branches per plant (5.8) over other two varieties. Foliar application of nutrients had significant influence on all the growth attributes of rapeseed-mustard varieties. Combined foliar application of macro and micronutrients, spraying of N:P:K (19:19:19) @2% twice at 30 DAS and 45 DAS+$ZnSO_4$ @ 0.05% at 40 DAS+Boron (20%) @ 0.1% at 50 DAS, exhibited significantly higher growth attributes such as plant height (98.1 cm), dry matter accumulation (386.9 g m^{-2}), LAI (2.52) and number of primary branches $plant^{-1}$ (5.3) when compared with other foliar spray of nutrients. Similar findings were earlier reported where application of fertilizers through foliar spray improved growth attributes like dry matter accumulation of *utera* crops over no-fertilizer (Sarkar et al., 2019) and Singh et al., 2021 in case of chickpea. Foliar spray of nutrients recorded maximum values for yield attributes to no spray due to application of balanced nutrition (Banerjee et al, 2019). The findings of Maji et al. (2018) supported this finding as they reported that foliar feeding at pre-flowering and pod development stages achieved superior relay lentil yield components and grain yield. Mudalagiriyappa et al., 2016 also found same trend in case of chick pea with more secondary branches, total dry matter accumulation and yield components in terms of pod number per plant, pod weight and final seed yield over control. No significant interaction between crop variety and foliar spray of nutrients on growth attributes were found.

3.2. Yield components and yield

Among different varieties of rapeseed mustard under study, variety PM 28 produced significantly highest number of siliqua $plant^{-1}$ (143.1), seed yield (1198.5 kg ha^{-1}), stover yield (3300.4 kg ha^{-1}) and biological yield (4498.8 kg ha^{-1}) over other two varieties (Table 1). This was followed by Binoy having highest number of seeds $siliqua^{-1}$ (17.7), seed yield (960.5 kg ha^{-1}), stover yield (2515.1 kg ha^{-1}), biological yield (3475.5 kg ha^{-1}) and Anushka having lowest number of siliqua $plant^{-1}$ (105.9), seed yield (817.9 kg ha^{-1}), stover yield (2022.4 kg ha^{-1}), biological yield (2840.4 kg ha^{-1}). The test weight was non-significant among the varieties. Harvest Index (H.I) of Anushka (yellow sarson) showed significantly higher value (0.29) than other two varieties.

Foliar spray of nutrients had a significant response to all yield attributing characters, yield and returns per rupee invested (Table 1) of *utera* rapeseed-mustard. Among different foliar spray of nutrients, foliar spray of N:P:K (19:19:19) @2% twice at 30 DAS and 45 DAS+$ZnSO_4$ @ 0.05% at 40 DAS+Boron (20%) @ 0.1% at 50 DAS was significantly superior to all other foliar sprays with respect to no. of siliqua $plant^{-1}$ (148.2), seeds $siliqua^{-1}$ (16.4), test weight (2.55 g) and seed yield (1233.2 kg ha^{-1}), stover yield (3109.9 kg ha^{-1}), biological yield (4343.2 kg ha^{-1}) and harvest index (0.29). Foliar application of nutrients was found superior to basal fertilization as the former provided an uninterrupted supply of nutrients for a wide growth period, which in turns enabled a steady translocation of the photosynthates resulted in an increase in crop yields (Sarkar et al., 2018). Earlier it was reported by Bhowmick, 2008, Gupta and Bhowmick, 2012 in lentil and Gupta and Bhowmick, 2013; Bhowmick et al., 2014 in lathyrus. Similar findings were also reported by Bhinda et al., 2023 and Meena et al., 2022 in mustard and Singh et al., 2021 in case of chickpea and Sarkar et al., 2019 in case of different pulses grown as *utera* crops in rice fallows. No significant interaction between crop variety and foliar spray of nutrients on yield component and yield of rapeseed-mustard was found.

3.3. Economics

PM 28 variety fetched significantly higher return per rupee investment (₹ 2.05) over B-9 (₹ 1.63) and Anushka

Table 1: Effect of different varieties and foliar spray of nutrients on growth and yield attributes, yield, H.I. and economics of utera rapeseed-mustard

Treat-ments	Growth attributes			Yield attributes			Test wt. (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	H.I.	RRI
	PHH	NPBP	LAI at 60 DAS	DMC	No. of siliqua plant^{-1}	Seeds siliqua^{-1}						
Rapeseed-mustard varieties (V)												
V_1	75.6	3.8	1.61	250.6	105.9	15.6	2.36	817.98	2022.40	2840.38	0.29	1.39
V_2	77.2	4.5	1.81	306.9	121.2	17.7	2.46	960.46	2515.06	3475.52	0.28	1.63
V_3	119.3	5.8	2.74	401.9	143.1	12.7	2.35	1198.46	3300.38	4498.83	0.27	2.05
SEm±	2.07	0.073	0.044	5.02	1.95	0.23	0.05	13.09	42.01	53.00	0.0014	0.021
CD (p=0.05)	6.74	0.24	0.142	16.37	6.37	0.74	NS	42.70	137.01	172.83	0.0045	0.069
Foliar spray of nutrients (F)												
F_0	82.7	3.7	1.64	257.6	86.28	13.0	2.04	774.22	2146.83	2921.06	0.27	1.47
F_1	90.8	4.8	2.03	323.7	128.44	15.2	2.45	1012.94	2659.61	3672.56	0.28	1.66
F_2	87.8	4.4	1.91	286.0	114.40	15.1	2.36	872.00	2329.94	3201.94	0.27	1.62
F_3	90.0	4.5	1.98	288.7	119.83	15.3	2.38	891.50	2361.44	3252.94	0.28	1.64
F_4	92.9	5.1	2.15	339.3	132.92	15.8	2.44	1076.72	2769.89	3846.61	0.28	1.73
F_5	94.1	5.1	2.18	359.0	137.63	16.3	2.49	1130.06	2959.11	4089.17	0.28	1.80
F_6	89.4	4.6	2.04	317.4	119.79	15.3	2.40	947.72	2564.11	3511.83	0.27	1.70
F_7	98.1	5.3	2.52	386.9	148.16	16.4	2.55	1233.22	3109.94	4343.17	0.29	1.93
SEm±	1.84	0.14	0.066	6.79	3.388	0.37	0.09	25.83	68.56	93.17	0.0018	0.044
CD (p=0.05)	5.18	0.39	0.18	19.11	9.53	1.04	0.24	72.64	192.82	262.01	0.0051	0.124
Interaction V×F												
SEm±	3.19	0.242	0.114	11.77	5.87	0.64	0.15	44.74	118.75	161.37	0.0031	0.077
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction F×V												
SEm±	3.63	0.238	0.115	12.1	5.83	0.64	0.15	43.85	118.76	159.98	0.0032	0.075
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

V_1: Anushka; V_2: B-9; V_3: PM-28; F_0: No foliar spray; F_1: Foliar spray with N: P: K (19:19:19) @ 2% at 30 DAS and 45 DAS; F_2: Foliar spray with $ZnSO_4$ @ 0.5% at 40 DAS; F_3: Foliar spray with boron (20%) @ 0.1% at 50 DAS; F_4: Spray 19:19:19 @ 2% at 30 DAS and 45 DAS+$ZnSO_4$ @ 0.5% at 40 DAS; F_5: Spray 19:19:19 @ 2% at 30 DAS and 45 DAS+Boron (20%) @ 0.1% at 50 DAS; F_6: Spray $ZnSO_4$ @ 0.5% at 40 DAS+Boron (20%) @ 0.1% at 50 DAS; F_7: Spray 19:19:19 @ 2% at 30 DAS and 45 DAS+$ZnSO_4$ @ 0.5% at 40 DAS+Boron (20%) @ 0.1% at 50 DAS; NS: Not significant; DAS: Days after sowing; LAI: Leaf Area Index; PHH: Plant height at harvest (cm); NPBP: No. of primary Branches plant^{-1} (at harvest); DMC: Dry matter accumulation (g m^{-2}) at harvest; RRI: Return rupee^{-1} investment (₹); 1US$= INR 72.46 and 78.6, respectively

(₹ 1.39) (Table 1). Economics of *utera* rapeseed-mustard was also significantly influenced by different foliar spray of nutrients over no foliar spray. Combined application of foliar nutrients viz. foliar spray of N:P:K (19:19:19) @ 2% twice at 30 DAS and 45 DAS+$ZnSO_4$ @ 0.05% at 40 DAS+Boron (20%) @ 0.1% at 50 DAS exhibited significantly higher return per rupee investment (₹ 1.93) over rest of the foliar spray of nutrients. Similar findings were also reported by Gupta and Bhowmick, 2013; Bhowmick et al., 2014 in lathyrus. No significant interaction was noticed so far as the economics of *utera* rapeseed-mustard was concerned between rice varieties and foliar spray of nutrients.

4. CONCLUSION

Mustard variety, PM-28 with foliar application of N:P:K (19:19:19) @ 2% twice at 30 DAS and 45 DAS+$ZnSO_4$ @ 0.05% at 40 DAS+Boron (20%) @ 0.1% at 50 DAS was a better proposition for enhancing yield and economic return from *utera* rapeseed-mustard grown in rice fallow of alluvial soils.

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