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Preeti Devatwal
Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology (MPUAT), Udaipur, Rajasthan, India

J Choudhary
Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology (MPUAT), Udaipur, Rajasthan, India

Sharvan Kumar Yadav
Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology (MPUAT), Udaipur, Rajasthan, India

Ravindra Kumar Jain
Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology (MPUAT), Udaipur, Rajasthan, India

Gajanand Jat
Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology (MPUAT), Udaipur, Rajasthan, India

Anita Todawat
Agriculture University, Jodhpur, Rajasthan, India

Corresponding Author:
Sharvan Kumar Yadav
Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology (MPUAT), Udaipur, Rajasthan, India

Effect of genotypes under varying fertility levels and bio-fertilizer inoculation on productivity and profitability of mustard [*Brassica juncea* (L.) Czern & Coss.]

Preeti Devatwal, J Choudhary, Sharvan Kumar Yadav, Ravindra Kumar Jain, Gajanand Jat and Anita Todawat

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Abstract
A field experiment "Effect of Genotypes under Varying Fertility Levels and Bio-fertilizer Inoculation on Yield, Yield Attributes and Economics of Mustard {*Brassica juncea* (L.) Czern & Coss.}'' was carried out at Instructional Farm of Agronomy, Rajasthan College of Agriculture, Udaipur, Rajasthan during *rabi* season of 2020-2021 in factorial randomized design (RBD). However, the treatment comprised of four genotypes *i.e.* Bio-902 (V1), Giriraj (V2), RH-0749 (V3) and NRCHB-101 (V4) and four fertility levels *i.e.* 75% RDF (F1), 100% RDF (F2), 75% RDF + Bio-fertilizer (F3) and 100% RDF + Bio-fertilizer (F4). Results clearly revealed that the entire yield, yield attributes and ultimately on economics were immensely influenced by genotypes and fertility levels. Yield and yield attributes *i.e.* seed, straw, biological, harvest index, primary, secondary, tertiary branches/plant, siliqua/plant, seed/siliqua and 1000 seed weight were increased with increasing the fertility levels. In among genotypes, Giriraj (V2) recorded significantly higher value of yield component *i.e.* seed, straw, biological, harvest index and yield attributes *i.e.* siliqua/plant and seed/siliqua. Further primary branches, tertiary branches and 1000 seed weight which were statistically at par with NRCHB-101(V4), Bio-902 (V1) and NRCHB-101(V4), respectively and significantly superior to RH-0749.Among the various fertility levels maximum yield and yield attributes were significantly obtained under 100% RDF+ Bio-fertilizer (F4) which was superior over rest of the treatments. However, significantly higher values of all the yield attributes and yield of mustard crop were observed with genotypes 'Giriraj' followed by NRCHB-101, Bio-902 and RH-0749 and fertility level 100% RDF + Bio-fertilizer as compare to other treatments. Relative economic analysis for crop cultivation indicated that the maximum gross return (₹/ha103762, 97238), net return (₹/ha83347, 77148) and benefit: cost ratio (4.09, 3.84) was found with Indian mustard variety 'Giriraj' with application of 100% RDF+ Bio-fertilizer.

Keywords: Yield, yield attributes and economics

Introduction
Mustard is second most important edible oil seed crop after soybean and known by the name of Indian mustard, belongs to the family Brassiceae (Cruciferae), genus Brassica and species juncea. Rapeseed is locally known as Sarson, Toria, Yellow Toria while mustard is named 'Rai' or 'Laha'. Mustard is a winter (*rabi*) season crop which requires low temperature, proper soil moisture during entire crop growth period and dry condition during harvest (Budzynski and Jankowski, 2019) [3].

The quality characteristics *viz.*, oil, protein, glucosinolate content and fatty acids. Oil content of its seeds ranges from 38- 46 per cent and possess adequate amount of erucic acid (40-60%) with linolenic up to 4.5 to 13 per cent. Mustard oil is good for human consumption and good for health because of rich source of the unsaturated fatty acids Brar *et al.*, 2016 [2]. At global level, India first position in area and second in production of mustard. Rapeseed-mustard crop occupies an area of 6.23 million ha in India with production and productivity of 9.34 million tonnes and 1499 kg/ha, respectively (Government of India, 2019-20) [7]. Rajasthan and U. P. are the major rapeseed and mustard growing states in the country. Rajasthan occupies 2.72 million ha area, 3.40 million tonnes production and 1558 kg/ha productivity (Economic survey, 2019) [6].

Bharatpur and Eastern districts are contributing about 48 per cent of the total production of the state.

Sulphur is an important element for synthesis of oil content in seeds and nitrogen is increase the mustard productivity and effect of fertility levels on seed and straw yield showed that application of 100% RDF found significantly higher seed and straw yield as compared to other treatments. Nitrogen is an integral component of amino and nucleic acids, proteins, nucleotides, chlorophyll, chromosomes, genes, ribosomes and also a constituent of all enzymes. Phosphorus is a constituent of several essential cell components like nucleotides, nucleic acids and phospholipids which promotes root development of the crop. Bio-fertilizers play an important role in the improvement of soil biological, physical and chemical properties. The use of bio fertilizers is also important to reduce the pollution rate in the soil and water. It plays vital role in integrated plant nutrient supply. PSB alone also have prominent effect due to that phosphorus helped in proliferation of root system. *Azotobacter* is non-symbiotic nitrogen fixing bio fertilizer having potential to fix considerable quantities of atmospheric nitrogen in the rhizosphere of non-legumes.

Materials and Methods

Study site

A field investigation was performed in mustard during *rabi* season during 2020-2021 at the Instructional Farm of Agronomy, Rajasthan College of Agriculture, Udaipur. The region falls under NARP agro-climatic zone IV a (Sub-Humid Southern Plain and Aravalli Hills) of Rajasthan, India. The site is situated at South-Eastern part of Rajasthan at an altitude of 581.13 m above mean sea level, 24°35' N latitude and 73°42' E longitude. The average rainfall of the region is 627.8 mm, most of which is mainly contributed by south west monsoon from June to September. The textural classes of the experimental soil was a clay loam in texture and slightly alkaline in reaction (pH 7.9), calcareous in nature and poor in organic carbon (0.69%). The total available N, P_2O_5 and K_2O were 282.3, 21.5 and 294.7 kg/ha, respectively.

Methods of data collection

The treatments were laid out in Factorial Randomized Block Design with three replications. The experiment consisted of four genotypes *i.e.* Bio-902, Giriraj, RH-0749 and NRCHB-101 and different fertility levels *i.e.* 75% RDF, 100% RDF, 75% RDF + Bio-fertilizer and 100% RDF + Bio-fertilizer. However, the recommended dose of fertilizer was applied as per treatment needs through Urea, DAP. Half dose of nitrogen and full dose phosphorus with Bio-fertilizer (PSB and *Azotobactor*) was applied at the time of sowing and remaining half dose of nitrogen was applied in two equal splits at branching and flowering. Mustard crop were raised with the seed rate of 5.0 kg/ha with the spacing of 30 cm x10 cm. Sowing of seeds was done by hand broadcasting method with furrow and cover the soil to ensure moisture loss through evaporation. Plant geometry were maintained by doing thinning and weeding operation at 15 DAS and 25 DAS respectively. Hence, all the other cultural operations were carried out as per the treatment needs. However, two irrigations were given at peak vegetative stage and pod filling stage to maintain optimum soil moisture for better growth & development of mustard and one last irrigation at maturity stage. Finally, plant protection measures were also done to protect the crop from mustard aphid with the application of spray of Imidacloprid 17.8% at 60 DAS at pod formation stage.

Results and Discussion

Effect on yield attributes

The higher value of yield attributes *i.e.* primary, secondary, tertiary branches, Siliqua plant^{-1} Seeds siliqua^{-1} and 1000 seed weight were recorded significantly higher under the genotype 'Giriraj' (5.61, 10.88, 3.35, 334.74, 15.01, 5.64) followed by NRCHB-101(5.45, 10.64, 3.06, 310.07, 13.95, 5.61), Bio-902 (4.94, 10.28, 3.20, 271.53, 11.75, 5.00) and RH-0749 (4.60, 10.20, 2.03, 250.81, 11.50, 5.06) (Table 1). But primary branches, tertiary branches and 1000 seed weight which were statistically at par with NRCHB-101, Bio-902 and NRCHB-101 respectively. The magnitude increased in respect of seed siliqua^{-1} in Giriraj was 27.74, 30.52 and 7.5 per cent, respectively. Enhancement of yield attributes might be due to the differential genetic potential of the genotypes which showed greater photosynthetic efficiency and it translocation to growing points which results faster growth and development. Our results are similarly found with Pachauri *et al*. (2012) [10].

Among the fertility levels the maximum yield attributes *i.e.* primary, secondary, tertiary branches, Siliqua/plant, seed/siliqua and 1000 seed weight (6.15, 11.64, 3.88, 341.61, 15.11 and 5.75) are obtained under 100% RDF+ Bio-fertilizer which were significantly higher over, 100% RDF, 75% RDF + Bio-fertilizer and 75% RDF. The increase in the siliqua/plant may be due to increase in branches under higher level of nitrogen and phosphorus application. With the application of higher level of fertilizers, the tissue differentiation from somatic to reproductive, meristematic activity and development of floral primordia. Higher fertility levels induced greater translocation of photosynthates from leaves to sink site. This resulted in bigger siliqua with higher seeds which on maturity become bold with highest test weight. This result is in accordance with the findings of Prem and Kumar, (2004) [11].

Effect on yields

The maximum seed, straw and biological yield were significantly observed under genotype 'Giriraj' compare to other genotypes. Genotype 'Giriraj' recorded seed yield1812 kg/ha followed byNRCHB-101 (1557kg/ha), Bio-902 (1380 kg/ha) (Table 2). The minimum seed yield was recorded with genotype 'RH-0749' (1221 kg/ha). Genotype 'Giriraj' was enhanced seed yield by means of 31.30, 48.31 and 16.36 per cent, respectively. The maximum straw and biological yield were also significantly obtained under genotype 'Giriraj' (5123 kg/ha and 6935 kg/ha). The magnitude of increased by means of 31.74, 50.05 and 16.81 per cent in straw yield and 31.62, 49.59 and 16.69 per cent in biological yield over Bio-902 (3889 kg/ha and 5269kg/ha), RH-0749 (3414 kg/ha and 4636 kg/ha) and NRCHB 101 (4386 kg/ha and 5943 kg/ha), respectively. Yield variations amongst mustard genotypes might be due to different genetic makeup Solanki *et al*., 2015. Higher seed and straw yield of 'Giriraj' genotype due to this aggressive growth attributes, better source and sink relationship which ultimately results in high yield. Our results are closely similar with findings of Kumar *et al*. (2000) [9].

Fertility levels were influenced on seed, straw and biological yield. The maximum seed, straw and biological yield were significantly observed under 100% RDF+ Bio-fertilizer compare to other fertility levels. 100% RDF+ Bio-fertilizer observed 1694 kg/ha followed by 100% RDF (1517), 75% RDF + Bio-fertilizer kg/ha (1501 kg/ha). The minimum seed yield was recorded with 75% RDF (1258 kg/ha). The magnitude increase of seed yield by means of 34.60, 11.68 and 12.86 per cent, respectively. The maximum straw and biological yield were also significantly obtained under 100% RDF+ Bio-fertilizer (5065 kg/ha and 6759 kg/ha). 100% RDF+ Bio-fertilizer (5065 kg/ha and 6759 kg/ha) was enhanced straw yield and biological yield by means of 57.17, 18.45 and 18.64 per cent and 51.45, 16.67 and 17.14 per cent, respectively over 100% RDF (4276 kg/ha and 5793 kg/ha) and 75% RDF + Bio-fertilizer (4269 kg/ha and 5770 kg/ha) and 75% RDF (3204 kg/ha and kg/ha 4462). Application of 100% RDF + Bio-fertilizer increase in overall yield might be due to tissue differentiation from somatic to reproductive, meristematic activity and development of floral primordial. Higher fertility levels induced greater translocation of photosynthates from leaves to sink site accordance with the findings of Bhari *et al*. (2016) [1] and Prem and Kumar. (2004) [11]. Similarly, results are found nitrogen application showed substantial increase in seed and straw yield of mustard by Singh and Verma, (2007) [12]. The balanced fertilization of mustard crop may be responsible to the effect of N on root proliferation, energy transformation and metabolic activities of the plant, which in term resulted in greater translocation of photosynthates towards the sink development finely yield increased Dongarkar *et al*. (2005) [14].

Effect on profitability

The maximum gross return, net return and B:C (103762 ₹ /ha, 83347 ₹/ha and 4.09) were obtained under genotype 'Giriraj' which was significantly higher over NRCHB-101 (89154 ₹/ha 68739 ₹/ha and 3.37), Bio-902 (79016 ₹/ha, 58601 ₹/ha and 2.88) and RH-0749 (69930 ₹/ha,49515 and 2.43) (Table 3). Increment in economics due to increased seed and biological yield of mustard.

Fertility levels influenced on profitability with different level of fertilizer. The maximum gross return, net return and B:C (97238 ₹ /ha, 77148 ₹ /ha,3.84) were observed under 100% RDF + Bio-fertilizer which was significantly higher over 100% RDF (86856 ₹/ha 66826 ₹/ha and 3.34), 75% RDF + Bio-fertilizer (85979 ₹/ha 65179 ₹/ha and 3.13) and 75% RDF (71790 ₹/ha 51050 ₹/ha and 2.46). The increment in economics might be due to application of phosphorus and potassium found higher monetary returns with increasing fertility levels as comparatively lower fertility. The similar results observed by Daulagupu and Thakuria (2016) [4] and Jat *et al*. (2017) [8].

Table 1: Effect of genotypes and fertility levels on yield attributes

Treatments	Yield attributes					
	Primary branches/plant	Secondary branches/plant	Tertiary branches/plant	Siliqua/plant	Seed/ siliqua	Test weight (g)
Mustard genotypes						
Bio 902	4.94	10.28	3.20	271.53	11.75	5.00
Giriraj	5.61	10.88	3.35	334.74	15.01	5.64
RH 0749	4.60	10.20	2.03	250.81	11.50	5.06
NRCHB 101	5.45	10.64	3.06	310.07	13.95	5.61
S.Em±	0.09	0.20	0.06	4.73	0.22	0.11
C.D. (P=0.05)	0.26	NS	0.17	13.65	0.63	0.33
Fertility levels						
75% RDF	4.49	9.60	2.14	248.55	11.14	5.00
100% RDF	5.02	10.37	2.82	289.42	13.03	5.28
75% RDF + Biofertilizer	4.93	10.38	2.80	287.57	12.94	5.27
100% RDF + Biofertilizer	6.15	11.64	3.88	341.61	15.11	5.75
S.Em±	0.09	0.20	0.06	4.73	0.22	0.11
C.D. (*P<0.05)	0.26	0.57	0.17	13.65	0.63	0.33

Table 2: Effect of genotypes and fertility levels on yield of mustard

Treatments	Yield				Harvest index (%)
	Seed yield (g/plant)	Seed yield (kg/ ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	
Mustard genotypes					
Bio 902	5.12	1380	3889	5269	26.77
Giriraj	5.71	1812	5123	6935	26.26
RH 0749	4.26	1221	3414	4636	26.55
NRCHB 101	5.40	1557	4386	5943	26.36
S.Em±	0.11	39.77	116.22	133.02	0.77
C.D. (P=0.05)	0.33	114.87	335.65	384.19	NS
Fertility levels					
75% RDF	4.86	1258	3204	4462	28.68
100% RDF	5.09	1517	4276	5793	26.21
75% RDF + Biofertilizer	5.05	1501	4269	5770	26.06
100% RDF + Biofertilizer	5.49	1694	5065	6759	25.01
S.Em±	0.11	39.77	116.22	133.02	0.77
C.D. (*p<0.05)	0.33	114.87	335.65	384.19	2.24

Table 3: Effect of genotypes and fertility levels on economics

Treatments	Economics		
	Gross return (₹/ha)	Net return (₹/ha)	B-C ratio
Mustard genotypes			
Bio 902	79016	58601	2.88
Giriraj	103762	83347	4.09
RH 0749	69930	49515	2.43
NRCHB 101	89154	68739	3.37
S.Em±	2215	2215	0.11
C.D. (P=0.05)	6398	6398	0.32
Fertility levels			
75% RDF	71790	51050	2.46
100% RDF	86856	66826	3.34
75% RDF + Biofertilizer	85979	65179	3.13
100% RDF + Biofertilizer	97238	77148	3.84
S.Em±	2215	2215	0.11
C.D. (*P<0.05)	6398	6398	0.32

Conclusion

It may be concluded that, maximum seed yield (1812 kg/ha), gross return (₹ 103762 /ha), net return (₹ 83347 /ha) and B-C ratio (4.09) was obtained with genotype Giriraj further, maximum seed yield (1694 kg/ha), gross return (₹ 97238 /ha), net return (₹ 77148 /ha) and B-C ratio (3.84) was realized under application of 100% RDF + Bio-fertilizer compared to other fertility levels. Hence, genotype Giriraj with the application of 100% RDF + Bio-fertilizer were proved economically viable in mustard crop under prevailing agro-climatic conditions of Rajasthan.

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