<u>*Original Research Article*</u>

Productivity, white rust and *Alternaria* blight of Indian mustard influenced by chemical fungicide seed treatment under humid southeastern Agro-climatic zone of Rajasthan, India

ABSTRACT

The purpose of this study was to evaluate the effect of different chemical fungicides application as seed treatment on growth, plant attributes and grain yields and incidence of diseases of Indian mustard. The field experiments was carried out in a randomized block design with three replications, consisting of 13 treatments namely no soaking control, water soaking, 1% KCl, 1% K_2SO_4, 1% $CaCl_2$, 1% NaCl, carbendazim 50% WP, mancozeb M-45, KCl + mancozeb M-45, K_2SO_4 + mancozeb M-45, $CaCl_2$ + mancozeb M-45, NaCl + mancozeb M-45, carbendazim 50% WP + mancozeb M-45. The result revealed that considerably maximum growth attributes (plant height, dry weight/plant, branches/plant, crop growth rate and relative growth rate), plant attributes (siliqua/plant, seeds/siliqua and test weight) and yields (seed, stover and biological) of Indian mustard observed when seeds treated with carbendazim 50% WP + mancozeb M-45 which were significant comparing with the rest of the treatments while it remained at par with K_2SO_4 + mancozeb M-45, KCl + mancozeb M-45 and mancozeb M-45. Seed treated with carbendazim 50% WP + mancozeb M-45 presented an increment of 111.96 and 95.67% in seed yield, 35.08 and 34.28% in stover yield and 48.72 and 45.8% in biological yield of crop as against to the no soaking control and water soaked treatment, respectively. In respect to percentage of disease incidence, maximum severity of white rust disease and *alternaria* blight diseases were observed under no soaking control and water soaked treatment. Minimum severity of white rust and *alternaria* blight diseases were recorded when seeds treated with carbendazim 50% WP + mancozeb M-45. According to our results, carbendazim 50% WP + mancozeb M-45 is the recommended treatment for seed before sowing that led to reducing white rust of leaf and *alternaria* blight diseases and enhancing the yields of crop with significant increase.

Keywords **:** *Alternaria* blight, Carbendazim, CGR, Mancozeb, RGR and White rust

1. INTRODUCTION

"Mustard (*Brassica juncea* L. Czern and Coss) is one of the most important edible oil seed crop in the world after soybean and groundnut crop" [12]. Vegetable oil has been an indispensable part of Indian households and kitchens and it contributes maximum shares of 40% of the production of all agricultural commodities globally. In India, different species of rapeseed-mustard is grown in different agro-climatic conditions. According to FAO [12] report "India is the largest importer of edible oils with 15% in the world followed by China and the USA. Indian vegetable oil economy is the world's fourth largest after the USA, China, and Brazil with total oilseed production of 34.2 million tonnes during 2019-20 and area of 26.0 Million hectares, mainly on marginal lands, depending on monsoon rains and with low levels of input usage". "In India, Rapeseed-mustard crop is cultivated in approximately 6.69 million hectare area with 10.11 million tonne production and 1511 kg/ha productivity" [2]. "It is largely cultivated in the states of Rajasthan, Uttar Pradesh, Haryana, Madhya Pradesh and Gujarat which contribute 81.5% in terms of area and 87.5% in term of production. In Rajasthan, it is grown in Alwar, Shri Ganganager, Bharatpur, Tonk, Sawai madhopur, Baran, Kota and Hanumangarh districts. Rapeseed-mustard crop is mostly used for various purposes such as cooking oil, medicinal, industrial uses and condiments. It is also rich in phyto-nutrients, minerals, vitamins as well as antioxidants constituents and serves as a functional food" suggested by Kumar and Andy [23].

"Indian mustard is typically grown in rainfed ecologies using conserved monsoonal moisture supported by a few winter rainfalls. Its cultivation has confined 50% of its total area only in Rajasthan state of the India. With efficient crop management practices in these areas, rapeseed-mustard can sustain the livelihood of a large number of marginal and poor farmers. The good management practices for mustard crop productions are required for proficient use of limited soil moisture available during the crop season especially at critical stages of crop growth. High evaporative demand and low soil organic carbon owing to poor crop management practices are restricting the national average productivity (1.09 tonne/hectare) of oilseed mustard as contrast to the world's average(1.980 tonne/hectare) in India and do up the livelihood of the majority of the farmers in arid to semi-arid regions of India" [10 and 41].

"Pesticides have become a key tool for plant protection and improvement of crops in the process of agricultural productivity" [43]. "Currently, approximately 4.0 million tonnes pesticides are used per year on a global basis, most of which herbicides (56%) are followed by fungicides (25%), insecticides (19%) and other types such as rodenticides and nematicides" [12 and 30]. "Globally, more than half of the pesticides are utilized in Asia. India stands twelfth position in global pesticide consumption and third in Asia after China and Turkey" [35]. A commonly used pesticide includes insecticides, fungicides and herbicides for management of uncontrolled weeds, insect pests and diseases in agricultural crops. However, in total pesticide consumption, insecticides occupies highest share in India. India share only one percent of the global pesticide use. According to the data of Directorate of Plant Protection, Quarantine and Storage [9], "India has utilized around 58720 tonnes of pesticide in 2021-22 and per hectare application rate of pesticide was only 0.31 kg in 2017". "Consumption in other countries like China, Japan and America was around 13.07, 11.76 and 3.57 kg/ha of pesticides, respectively" [34]. "So, it is clear that India uses fewer amounts of pesticides in per hectare of crop land area, but uncontrolled and hazardous use of pesticide is responsible for the presence of high pesticide residues in both natural and physical environment. Pesticides are toxic chemicals used on arable fields to control different diseases, insect pests and weeds so as to decrease yield losses and also sustain high productivity of crops" [16]. "Application of pesticide is strategy for effective management of insect pest and diseases and the productivity of crops depends on their effective management" [38]. "Pesticides are extensively used in all over the world to control different insect pest population and among them; fungicides are specially used to control fungal plant pathogens" [27 and 51]. "Non-target and excessive use of chemical fungicides have caused environmental pollution and development of fungicide resistance in plant pathogens which led to the search for alternative methods" [17].

"Fungicides are mainly used to control many diseases on wide range of crops" [26, 28 and 37]. "Mancozeb (polymeric complex of 20% Manganese and 2-5 % Zinc salt of EBDC group) is a fungicide of the carbamate pesticide family. It is marketed by the various trade names like Dithane M45, Indofill, Manzeb, Nemispot, Manzane etc. It is applied on various crops including oil producing crop plants, food grain field crops and other fruit crops against a wide spectrum of fungal diseases" [36]. Vuyyuru, *et al.* [47] reported that "application of fungicides in the soil improved early root and shoot growth and plant establishment that can potentially reduce the yield decline in successively planted sugarcane in histosols". "In current times, crop suffers from different diseases out of them, white rust and *Alternaria* blight [*Alternaria brassicae*

(Berk.) Sacc. & *A. brassicicola* (Schw.)] are serious and widely occurred diseases in mustard crop all over the country" [6 and 29]. Chattopadhyay *et al.* [5] reported that "*Alternaria* blight causes blight of leaf, pod, stem and seed abnormalities". According to Rathi *et al.* [40] and Monika and Kidwai [33] it was reported that "*Alternaria* blight reduce upto 70% yield of mustard in India". "Mancozeb has power to inhibit spore formation in pathogenic fungi, thereby causing its death [11] and also associated with several health hazards when applied in very high doses. White rust disease in Indian mustard usually appears at the time of flowering as shiny white to creamy yellow raised pustules on lower surface of leaves". "Later on, under severe cases, white pustules may also appear on stem inflorescence and pods. In white rust, Staghead formations (presence of swollen, twisted and distorted inflorescences) are quite common due to systemic infection" [31]. "White rust incited by the biotrophic oomycete pathogen, *Albugo candida*, is the serious fungal disease that causes enormous yield loss of 89.8% in India due to infection at leaf phase and hypertrophy of flowers and pods" [24]. Yadav *et al.* [49] reported that "the losses could be in the range from 17 to 44% in India. There is very little information available with regard to the effect of chemical fungicide as seed treatment in oil crops generally and on mustard crop particularly. Therefore, the present study was undertaken with a view to know the effect of fungicide seed treatment on growth and yields and severity of diseases particularly white rust and *alternaria* blight on Indian mustard (*Brassica juncea* L.) under semiarid conditions of Rajasthan".

2. MATERIALS AND METHODS

The field experiment of a mustard crop was conducted at the Instructional Farm (Agronomy), Career Point University, Kota during winter season situated in southeast part of Rajasthan at an altitude of 579.5 meter above mean sea level and 24º35' N latitude and 73º42' E longitude. The region falls under humid southeastern agro climatic zone of Rajasthan. The soil was medium black and having neutral pH, medium in organic carbon (0.67%), available nitrogen and available potassium, and low in phosphorus. In this experiment, 13 treatments were laid out in randomized block design with three replications and comprised of thirteen treatments of chemical seed treatments namely no soaking control, water soaking, 1% KCl, 1% K_2SO_4, 1% $CaCl_2$, 1% NaCl, Carbendazim 50% WP, Mancozeb M-45, KCl + Mancozeb M-45, K_2SO_4 + Mancozeb M-45, $CaCl_2$ + Mancozeb M-45, NaCl + Mancozeb M-45, Carbendazim 50% WP +

Mancozeb M-45. Healthy seeds of mustard were sown at the depth of 3-4cm, keeping inter-row spacing of 45 cm apart using a recommended seed rate of 4 kg/ha. Before sowing, Seeds were treated with chemicals as per treatments. The crop was fertilized with full recommended dose of phosphorus and half dose of nitrogen as basal just before sowing the seed through DAP and urea and remaining half dose of nitrogen was applied as top dressing at 40 days after sowing. Intercultural operations, thinning and weeding were carried out as and when required. Observations on growth, yield attributes and yield of mustard were recorded. Crop growth rate (g $m^{-2}day^{-1}$) and relative growth rate (g $g^{-1}day^{-1}$) at different growth stages of mustard crop was calculated by using the following formula as described by Hunt [18] and Gardner *et al.* [13], respectively.

$$\text{Crop Growth Rate} = \frac{W_2 - W_1}{t_2 - t_1}$$

$$\text{Relative Growth Rate} = \frac{(\text{Log}_e W_2 - \log_e W_1)}{t_2 - t_1}$$

Where: W_2 and W_1 was the dry weight of plant and t_2 and t_1 was times of sampling,

$\log_e$ value = 0.4342945.

The severity percentage of white rust and *Alternaria* blight diseases were observed in experimental plots by examining the plant parts like leaves and pods with the help of the standard pictorial scale proposed by Conn *et al.* [7]. The data collected in percentages were processed using angular transformation and they were analyzed statistically by using analysis of variance [15] to calculate the least significant difference (LSD) between treatment means (P = 0.05).

3. RESULT AND DISCUSSION

3.1 Growth attributes

It is evident from the table 1-3 that plant height, number of branches per plant, dry weight per plant, crop growth rate and relative growth rate at different crop stages were significantly increased by fungicide seed treatments as compared to no soaking control and water soaked treatment. Maximum plant height (55.67cm at 40 DAS) was recorded when seeds treated with carbendazim 50% WP + mancozeb M-45 and significantly superior over rest of the treatments but at par with K_2SO_4 + mancozeb M-45, KCl + mancozeb M-45 and mancozeb M-45. At 60 DAS, maximum plant height of 95.49 cm recorded with carbendazim 50% WP + mancozeb M-45 being at pat to K_2SO_4 + mancozeb M-45, KCl + mancozeb M-45, mancozeb M-45, carbendazim 50% WP, NaCl + mancozeb M-45 and $CaCl_2$ + mancozeb M-45 and significant higher than the rest of the treatments. While at 80 DAS, carbendazim 50% WP + mancozeb M-45 treatment recorded the highest plant height (165.3cm) being statistically at pat with K_2SO_4 + mancozeb M-45, KCl + mancozeb M-45, NaCl + mancozeb M-45, $CaCl_2$ + mancozeb M-45, mancozeb M-45 and carbendazim 50% WP and significant over the rest of the treatments. Maximum plant height increase was recorded between 60 to 80 days after sowing. Rokib and Monjil [42] reported that seeds treated with dithane M-45 produced seedlings with higher shoot length, root length and seedling vigour followed by Deconil. At 20 DAS, higher percentage increased vigour index over control was found when using dithane M-45 (24.64%) and deconil (22.44%), respectively. Mohammed and Alrajhi, [32] reported that maximum shoot length (11.78%) of chickpea was found when seeds were treated with Secure 600WG (Mancozeb+Fenamidon), while maximum root length (21.80%) was recorded when seeds were treated with Provax 200WP (Carboxin+Thiram) over control. Total number of branches per plant at different crop stages was improved with fungicide seed treatments. At 80 DAS, the highest number of branches/plant recorded when seeds were treated with carbendazim 50% WP + mancozeb M-45 (7.35) and significant as compared to the rest of the treatments except KCl + mancozeb M-45 and K_2SO_4 + mancozeb M-45 treatment. However, seed treated with carbendazim 50% WP + mancozeb M-45, KCl + mancozeb M-45 and K_2SO_4 + mancozeb M-45 were at par to each others. Number of branches per plant continued up to 80 DAS and maximum increase in number of branches/plant was noted at 40 DAS. Total dry biomass accumulation at different crop stages was improved with fungicide seed treatments as compared to control and water soaked treatment (Table 2). Dry matter accumulation continued with the age of crop. Highest biomass accumulation at 40 day after sowing was recorded with carbendazim 50% WP + mancozeb M-45 treatment seeds which were significant over the rest of the treatments. While, treatment of KCl + mancozeb M-45 and K_2SO_4 + mancozeb M-45 was at par with carbendazim 50% WP + mancozeb M-45 combination. At 60 day after sowing, maximum biomass accumulation (11.05 g/plant) was recorded with carbendazim 50% WP + mancozeb M-45 which was significant as compared to the rest of the treatments. Treatment of KCl + mancozeb M-45 (10.16 g/plant) and K_2SO_4 + mancozeb M-45 (10.58 g/plant) was at par with carbendazim 50% WP + mancozeb M-45 and also significant over the rest of the treatments in respect to the total biomass accumulation of mustard crop. At 80 days after sowing, maximum total biomass accumulation (21.27 g/plant) recorded when seed treated with carbendazim 50% WP + mancozeb M-45 and significant over the rest of the treatments but at par with carbendazim 50% WP, mancozeb M-45, KCl + mancozeb M-45, K_2SO_4 + mancozeb M-45, $CaCl_2$ + mancozeb M-45, NaCl + mancozeb M-45 and KCl treatment. Maximum dry matter increase was recorded between 60 to 80 days after sowing. The improvement in the above growth attributes at different growth stages might be due to the favourable effect of chemical fungicide treatments in initial stage in the soil and kill the harmful pathogens and protects from soil borne diseases. Optimum use of fungicides didn't causes any deleterious impact on soil microflora, nitrification, soil microbial biomass, carbon mineralization and soil enzymes which may result in beneficial effects on nutrient uptake and plant growth [25 and 37]. Vuyyuru, *et al.* [47] reported that that mancozeb as soil application improved sugarcane shoot and root dry matter by 3-4 times and shoot-root length, fine-root length, and root surface area by 2-3 times compared to untreated soil.

The crop growth rate of mustard crop at different stage was influenced by fungicide seed treatments as compared to no soaking control and water soaked treatments (Table 2). The crop growth rate was continued to 80 days after sowing and represent maximum increment between 60-80 DAS. During 20-40 DAS, maximum crop growth rate of 4.585 g $m^{-2}day^{-1}$ was recorded when seeds treated with carbendazim 50% WP + mancozeb M-45 and significant over the rest of the treatments but it remained at par with K_2SO_4 + mancozeb M-45 treatment. While, seed treatment with carbendazim 50% WP + mancozeb M-45 showed maximum crop growth rate of 13.754 g m^{-2} day^{-1} between 40-60 DAS which was significant over the rest of the all treatments. Between 60-80 DAS, considerable higher crop growth rate of 22.131 g $m^{2}day^{-1}$ was observed with the seed treatment of carbendazim 50% WP + mancozeb M-45 remained at par with K_2SO_4 + mancozeb M-45 and KCl + mancozeb M-45 and significant as compared to the rest of all treatments. Further result revealed that relative crop growth rate of mustard was also improved by fungicide seed treatments between 20-40 DAS (Table 3). Between 40-60 DAS, significantly higher relative growth rate (0.094 g $g^{-1}day^{-1}$) was noted with carbendazim 50% WP + mancozeb M-45 which was significant over the rest of all the treatments. However, between 60-80 DAS, maximum relative growth rate of the mustard crop was recorded with carbendazim 50% WP + mancozeb M-45 and significant over the rest of the treatments but it remained at par with K_2SO_4 + mancozeb M-45, KCl + mancozeb M-45 and mancozeb M-45. The enhancement in crop growth rate and relative growth rate of crop might be owing to higher biomass production and fast photosynthetic activity of crop [37 and 45].

3.2 Plant attributes and yields

The data presented in table 3 shows that the number of siliqua per plant, number of seeds per siliqua and test weight of mustard crop was considerably improved by different chemical fungicide seed treatments. Seed treated with carbendazim 50% WP + mancozeb M-45 recorded significantly the highest number of siliqua per plant as compared to the rest of the treatments but it remained at pat with K_2SO_4 + mancozeb M-45. However, all other chemical fungicide treatments also enhanced the number of siliqua per plant of mustard as against to no soaking control and water soaked treatments. In terms of the number of seeds per siliqua and test weight of mustard, carbendazim 50% WP + mancozeb M-45 treatment found significantly superior over the rest of the treatments. The percentage of increment in number of seed per siliqua was 78.01 and 69.27 and in test weight was 70.32 and 63.18% higher than the no soaking control and water soaked treatments, respectively. However, all other chemical fungicide seed treatments were statistically at par to each other and significantly superior to the control and water socked treatments. The increase in the plant attributes could be also ascribed to overall improvement in plant growth attributes and vigour with chemical fungicide treatments that favoured the healthy soil environment with no fungal infection of diseases, better utilization of factors like genetic potentiality of the crop variety, irrigation, fertility, active solar radiation and formation of grain and its development which resulted into increase in the number of siliqua, number of seed and test weight of mustard seed [3, 8, 37 and 45]. Khalil *et al.* [21] reported that fungicides treatments significantly increased the seedling emergence, plant height, number of grains per spike, 1000 grain weight, grain yield per plot and per hectare over control. Our findings are close proximity of Yadav *et al.* [50] and Getachew and Abeble[14].

Scrutiny of data revealed that chemical fungicide seed treatment significantly enhanced the seed yield, stover yield and biological yield of mustard crop (Table 4). Maximum seed yield of 2215 kg/ha recoded when seeds treated with carbendazim 50% WP + mancozeb M-45 which was significant over the rest of the treatments and accounted 111.96 and 95.67% as compared to the no soaking control and water soaked treatment. While, carbendazim 50% WP + Mancozeb M-45 treatment remained at par with K_2SO_4 + mancozeb M-45, KCl + mancozeb M-45, mancozeb M-45, carbendazim 50% WP and $CaCl_2$ + mancozeb M-45. All fungicide treatments also increase seed yield in comparison to the no soaking control and water soaked treatments. The highest stover yield of 6561 kg/ha noted with carbendazim 50% WP + mancozeb M-45 that was found significant over the rest of the treatments except K_2SO_4 + mancozeb M-45, KCl + mancozeb M-45 and mancozeb M-45. carbendazim 50% WP + mancozeb M-45 treatment increased the stover yield by 35.08 and 34.28% over no soaking control and water soaked treatment, respectively. However, all other chemical fungicides also increased the seed yield as compared to no soaking control and water socked treatments. In respect to the biological yield, maximum value of 8776 kg/ha observed when seeds were treated with carbendazim 50% WP + mancozeb M-45 and significant over the rest of the treatments but remained statistically at par with K_2SO_4 + mancozeb M-45, KCl + mancozeb M-45, mancozeb M-45, carbendazim 50% WP and $CaCl_2$ + mancozeb M-45. The treatment of carbendazim 50% WP + mancozeb M-45 caused a significant increase in biological yield of crop by 48.72 and 45.8% over the no soaking control and water soaked treatments, respectively. The chemical fungicide seed treatments were failed to bring significant improvement in harvest index of crop but they were higher than the no soaking control and water soaked treatments. Marked variation in yields of mustard crop obtained under different chemical fungicide treatments might be due to effective disease control at initial stages and favourable soil condition for nutrition acquisition and uptake which led to increase in the growth and plant attributes [20]. Biological yield is cumulative effect of seed and stover yields of mustard. Use of chemical fungicide treatments not only reduce the incidence of diseases but also help the crop for better utilization of nutrients from soil and optimum utilization of agronomic and environmental factors (solar ration) which exert their utmost strength in achieving the more economic yield [44-45 and 50]. Kumar and Rathi [22] found that foliar spray with mancozeb (0.2%) at 45 DAS increased seed yield by 29.9 per cent as compared to untreated control. Jackson and Kumar [19] reported that use of mancozeb 75% (Indofil M-45) increased the seed yield of mustard by 51.2% as compared to control. Our findings are supported by Akinbo *et al.* [1], Mathivanan and Prabavathy [28], Meena *et al.* [29], Yadav *et al.* [48], Ramesh and Zacharia [39] and Getachew and Abeble [14].

3.3 Diseases Severity

Further findings in table 4 showed that reduced percent incidence of white rust and *alternaria* blight diseases in Indian mustard was observed when seeds treated with all chemical fungicide seed treatments. Maximum severity of white rust and *alternaria* blight diseases in mustard crop was recorded with the no soaking control and water soaked treatments. Minimum severity of white rust and *alternaria* blight diseases was observed when seed treated with carbendazim 50% WP + mancozeb M-45 and had significant effect on reducing white rust severity and *alternaria* blight severity as compared to rest of the treatments. However, all other treatments except the no soaking control and water soaking treatment also reduce the percent incidence of both diseases (white rust and *alternaria* blight) on mustard. Sumitra *et al.* [46] reported that carbendazim + mancozeb was found most effective in reducing per cent disease intensity (78.81%) of mustard crop followed by mancozeb (74.71%) and copper oxychloride (70.09%). Kumar and Rathi [22] reported that foliar spray with mancozeb (0.2%) at 45 DAS was found most effective in controlling Alternaria leaf blight severity up to 78.0% and Alternaria pod blight severity up to 56.5% as compared to untreated control. Similar results were reported by Getachew and Abeble [14] and Bairwa *et al*. [4].

4. CONCLUSION

On the basis of findings from this study it might be concluded that chemical fungicide seed treatment with carbendazim 50% WP + mancozeb M-45 was found more effective in reducing the percent severity of white rust and *alternaria* blight diseases on mustard crop as well as improving yields of crop with significant increase that helps in stability of crop productivity.

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Table 1. Effect of chemical fungicides seed treatment on plant height and number of branches/per plant of Indian mustard

Treatment	Plant height (cm)				Total number of branches/plant		
	20 DAS	40 DAS	60 DAS	80 DAS	40 DAS	60 DAS	80 DAS
No soaking control	1.01	32.22	68.14	135.15	1.2	2.87	3.93
Water soaking	1.16	33.26	71.84	142.65	1.16	3.37	4.13
1% KCl	1.37	41.28	83.38	150.21	1.53	4.23	6.33
1% K_2SO_4	1.35	39.68	81.81	148.34	1.46	4.11	6.13
1% $CaCl_2$	1.29	36.94	73.71	144.75	1.33	3.77	5.81
1% NaCl	1.17	35.61	75.28	143.89	1.27	3.67	5.66
Carbendazim 50% WP	1.57	45.41	85.41	154.12	1.86	4.63	6.77
Mancozeb M-45	1.62	45.72	88.42	157.1	2.16	4.87	6.89
% KCl + Mancozeb M-45	1.67	51.07	91.64	158.71	2.59	5.33	7.01
1% K_2SO_4 + Mancozeb M-45	1.76	53.55	92.91	160.43	2.73	5.63	7.213
1% $CaCl_2$ + Mancozeb M-45	1.51	44.72	85.26	152.91	1.66	4.43	6.67
1% NaCl + Mancozeb M-45	1.41	43.41	85.48	150.45	1.6	4.37	6.49
Carbendazim 50% WP + Mancozeb M-45	1.82	55.67	95.49	165.33	2.81	5.73	7.35
SEm (±)	0.19	2.84	3.64	5.32	0.14	4.83	0.43
LSD *(P=0.05)*	NS	8.28	10.64	15.54	0.40	14.11	1.26

Table 2. Effect of chemical fungicide seed treatment on plant dry weight and crop growth rate of Indian mustard

Treatment	**Dry weight/plant (g)**			**Crop Growth Rate (g m^{-2} day^{-1})**		
	40 DAS	**60 DAS**	**80 DAS**	**20-40 DAS**	**40-60 DAS**	**60-80 DAS**
No soaking control	0.85	5.44	13.5	1.385	7.51	13.426
Water soaking	1.34	6.14	14.49	2.145	7.616	13.693
1% KCl	2.02	7.61	18.69	3.238	8.005	18.148
1% K_2SO_4	1.71	7.11	18.16	2.916	7.644	17.593
1% $CaCl_2$	1.68	6.89	17.11	2.748	7.649	16.882
1% NaCl	1.64	6.48	16.27	2.711	7.616	16.759
Carbendazim 50% WP	2.11	9.27	19.22	3.443	8.955	19.615
Mancozeb M-45	2.24	9.87	19.89	3.694	9.921	19.909
% KCl + Mancozeb M-45	2.39	10.16	20.86	3.835	11.538	20.298
1% K_2SO_4 + Mancozeb M-45	2.62	10.58	21.06	4.283	12.021	21.026
1% $CaCl_2$ + Mancozeb M-45	2.06	8.45	18.94	3.274	8.682	19.037
1% NaCl + Mancozeb M-45	2.03	8.1	18.87	3.27	8.477	18.615
Carbendazim 50% WP + Mancozeb M-45	2.81	11.05	21.27	4.585	13.754	22.131
SEm (±)	0.16	0.37	0.96	0.21	0.44	0.85
LSD *(P=0.05)*	0.45	1.09	2.81	0.62	1.29	2.48

Table 3. Effect of chemical fungicides seed treatment on relative growth rate, number of siliqua/plant, number of seed/siliqua and test weight of Indian mustard

Treatment	**Relative Growth Rate (g g^{-1} day^{-1})**			**Number of Siliqua/plant**	**Number of seeds/siliqua**	**Test weight (g)**
	20-40 DAS	**40-60 DAS**	**60-80 DAS**			
No soaking control	0.152	0.057	0.033	133.28	8.14	2.84
Water soaking	0.158	0.059	0.038	169.47	8.56	2.96
1% KCl	0.216	0.066	0.045	250.07	11.01	4.01
1% K_2SO_4	0.196	0.063	0.042	247.47	10.58	3.88
1% $CaCl_2$	0.166	0.063	0.042	226.33	10.49	3.70
1% NaCl	0.162	0.059	0.041	193.4	9.70	3.37
Carbendazim 50% WP	0.243	0.069	0.048	264.93	13.20	4.29
Mancozeb M-45	0.247	0.070	0.051	272.6	13.53	4.44
% KCl + Mancozeb M-45	0.248	0.073	0.052	295	13.77	4.48
1% K_2SO_4 + Mancozeb M-45	0.251	0.077	0.053	303.27	14.01	4.69
1% $CaCl_2$ + Mancozeb M-45	0.239	0.066	0.046	261.72	12.66	4.17
1% NaCl + Mancozeb M-45	0.237	0.066	0.045	250.87	12.36	4.09
Carbendazim 50% WP + Mancozeb M-45	0.266	0.094	0.055	329.13	14.49	4.83
SEm (±)	0.032	0.004	0.002	9.94	0.87	0.26
LSD *(P=0.05)*	NS	0.011	0.006	29.01	2.55	0.75

Table 4. Effect of chemical fungicides seed treatment on yields and white rust and *Alternaria* blight diseases of Indian mustard

Treatment	**Yields (kg/ha)**			**HI**	***White rust**	***Alternaria* blight**
	Seed	**Stover**	**Biological**	**(%)**	**(% severity)**	**(% severity)**
No soaking control	1045	4857	5901	0.18	51.42 (61.14)	43.69 (47.74)
Water soaking	1132	4886	6019	0.19	51.07 (60.56)	43.07 (46.66)
1% KCl	1588	5280	6868	0.23	45.69 (51.24)	38.06 (38.04)
1% K_2SO_4	1420	5121	6541	0.22	41.96 (44.93)	38.41 (38.63)
1% $CaCl_2$	1395	5099	6493	0.21	48.11 (55.44)	39.02 (39.64)
1% NaCl	1282	5043	6325	0.20	49.45 (57.76)	40.29 (41.96)
Carbendazim 50% WP	1973	6084	8057	0.25	39.09 (39.77)	31.97 (28.08)
Mancozeb M-45	2041	6262	8303	0.25	36.62 (35.62)	31.17 (26.82)
% KCl + Mancozeb M-45	2107	6383	8490	0.25	35.65 (34.01)	30.38 (25.61)
1% K_2SO_4 + Mancozeb M-45	2176	6480	8656	0.26	35.07 (33.06)	28.72 (23.16)
1% $CaCl_2$ + Mancozeb M-45	1870	5840	7710	0.24	40.84 (42.80)	33.12 (29.90)
1% NaCl + Mancozeb M-45	1691	5543	7234	0.23	41.25 (43.54)	34.65 (32.39)
Carbendazim 50% WP + Mancozeb M-45	2215	6561	8776	0.25	31.13 (26.76)	27.09 (20.76)
SEm (±)	120	372	414	0.02	1.88	1.55
LSD *(P=0.05)*	351	1087	1207	NS	5.53	4.51

*LSD (P = 0.05) for angular transformed values. a Figures in parenthesis are actual values and others are angular transformed ones.
HI-harvest index