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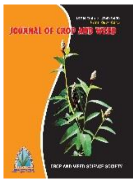

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Research Article

Weed dynamics and productivity of zero tilled mustard as influenced by integrated nutrient management under rice – mustard sequence

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ABSTRACT

A field experiment was conducted to find out the influence of integrated nutrient management on zero tilled mustard crop at Instructional Farm, Jaguli, Nadia under Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, West Bengal, India during the rabi season (2019-2020 and 2020-2021) in alluvial soil. Application of Suphala along with N and K_2O was recorded to be best in terms of weed count (48 m^{-2}) and weed control efficiency (62.5%) at harvest. Maximum seed yield of hybrid mustard, Keshari 5111 (858 kg ha^{-1}) was recorded in application of Suphala + N @ 30 kg ha^{-1} at 30 DAS+ B @ 0.25%. The maximum oil percentage of 43.5% was noted with the application of Suphala + N @ 30 kg ha^{-1} at 30 DAS. The combined application of Suphala + N along with B enhanced the yield and quality attributes of hybrid mustard in the new alluvial soils of West Bengal, India.

Keywords: Zero tillage, weed dynamics**,** growth, hybrid mustard, oil percentage and yield

Global population is rising gradually, which is likely to be a serious challenge in food security. This can be overcome by enhancing production of major crops. On the oilseed production scenario of the world, India holds a prominent position with fourth biggest oilseed economy worldwide, both in respect to acreage and production and among the top few vegetable oil economies across the globe next to food grains. Europe is the prime producer of mustard seed around the globe estimating around 35% of the production worldwide followed by China (22%), Canada (21%) and India (11%) (GOI, 2018). Rapeseed and mustard contributes 27.8% in the India's oilseed economy with the mean productivity has been accounted at 1,203 kg ha^{-1} during 2022-23, leading to the whole mustard production almost 115.25 lakh tonnes. In general seed of mustard contains 30-33% of oil, 18-27% proteins, 9-11% fibres and 10-12% extractable substances which is mostly use as an edible oils, consumed as spices, condiments and often feeding materials for cattle (Jakhar *et al*., 2018). Under West Bengal situation, mustard crop productivity is lower than developed nations primarily for its poor agro ecological conditions like inadequate soil nutrients, poor soil structure, insufficient or extreme rainfall, high temperature, unavailability of land due to late harvesting of rice, late sowing, improper fertilization and absence of proper agronomic management. The ideal conditions for growing rapeseed and mustard must be cool to moderate climate, well drained loamy or sandy loam soil with pH 6.0 to 7.5, well balanced fertilizer and timely sowing. Keeping in view the different agro ecological problems, focus should be on the conservation agriculture, zero tillage (ZT). It is an integral part that has gained much attention for lesser irrigation demand, improved soil fertility, higher profit margins, minimizes cost of tillage and protects the soil from erosion and lowering the organic matter depletion. The dominating weed flora in mustard field are *Argemone mexicana*, *Avena fatua*, *Chenopodium album*, *Convulvulous arvensis* etc. Hence the mustard crop suffers from weed competition particularly at early crop growth stage and is a major recognized bottleneck in regarding to yield potential of mustard. The yield loss due to presence weeds varies between 25– 45% depending on the weed flora, stages, nature and period of crop weed competition (Meena and Sharma, 2019).

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Integrated nutrient management (INM) is the prudent application of all possible sources of nutrient to fulfil the nutrient demand essential for plant growth at a favourable level to sustain the desired crop productivity on a long-term basis for increasing the available plant nutrients and enhances the soil properties through enhancing the nutrient use efficiency and boosting the soil health (Karmakar *et al*., 2022). Kaur and Kumar (2022) stated that application of integrated nutrient management significantly influenced the number of plant height (cm), number of leaves plant^{-1}, number of branches plant^{-1}, fresh and dry weight plant^{-1} in mustard. The highest seed yield was recorded with the application of 100% RDF+2 t FYM ha^{-1}+20 kg $ZnSO_4$ ha^{-1}+ 1 t vermicompost ha^{-1}+ *Azotobacter* seed treatment compared to other treatments. Sreerenjiny and Debbarma (2022) reported that treatments consist of 75% nitrogen through vermicompost + 25% nitrogen through urea significantly influenced higher plant height (199.96 cm), maximum number of branches (12.27), number of siliquae plant^{-1} (272.42), number of seeds silique^{-1} (14.24) dry weight (28.40 g). It is also observed that the higher seed yield (2.19 t ha^{-1}) and higher stover yield (3.34 t ha^{-1}) was obtained with the application of 75% nitrogen through vermicompost + 25% Nitrogen through urea. Higher gross return (119619.5), net return (86,674), benefit cost ratio (2.63) was obtained under the use of 75% nitrogen through vermicompost + 25% Nitrogen through urea. Foliar application is known for its rapid and effective utilization of applied nutrients, minimizes the leaching losses and regulating the plant nutrient uptakes. It is regarded as a vital strategy to fertilize crops for the critical growth stages as the nutrients applied can directly enter through leaf cuticles and reduce cost of cultivation (Saikh *et al*., 2022). Nitrogen is an important element that has a great role in chlorophyll formation, is essential for the photosynthesis and portion of various enzymatic proteins that can catalyse plant development processes. Bankoti *et al*. (2021) experimented an experiment with 6 levels of nitrogen doses as factor A (0, 20, 40, 60, 80, 100 and 120 kg ha^{-1}). It was revealed that application of 100 kg N ha^{-1} recorded significantly maximum growth attributes *viz*., plant height (cm), number of total branches plant, dry weight at harvest stage, yield attributes (no of siliquae per plant, length of siliquae per plant, number of seed per siliquae, seed weight per siliquae, 1000 seed weight, seed weight per plant) and yield and harvest index, besides achieved better quality. Phosphorus is an essential macronutrient that can stimulate root, and grain development via crucial metabolic activities such that photosynthesis, carbon partition, sugar transport, energy storage, transfer, etc. (Hachiya and Sakakibara, 2016). Potassium has a potential in plant metabolism, regulates the stomata movement, tolerance towards diseases and drought (Singh and Rathi, 2010). Indian soils are deficiency in zinc which is efficiently involved in the metabolism of nitrogen and also an act as chief source of various enzymes and proteins necessary for plant body (Mondal *et al*., 2020; Sarkar *et al*., 2021). Boron (B) is considered as a vital component of cell wall formation and has a great potential in translocation of photosynthates and has a vital role in pollen viability and development (Jana *et al*., 2020). Application of farm yard manure can influence soil properties through improving water holding capacity as well as efficiency the microbial growth and activity by providing vitamins and growth hormones supplies all necessary nutrients is required for plant growth which have a direct role on plant growth leads to better agriculture production. Weeds are one of the key constraints in crop production competing with plants for moisture, nutrients, light, and space, and consequently causes in higher yield loss almost 65% depending on the nature and density of weed species (Mishra *et al*., 2021). Therefore, an experiment was performed to judge the weed dynamics and productivity of zero tillage mustard var. Kesari-5111 influenced by integrated nutrient management under rice – mustard sequence in the *Gangetic* alluvial soil of West Bengal.

MATERIALS AND METHODS

A field observation was conducted at Jaguli Instructional Farm (22°93' N latitude, 88°53' E longitude and 9.75 m above mean sea level) of Bidhan Chandra Krishi Viswavidyalaya, Jaguli, Nadia, West Bengal, India during rabi seasons of 2019-20 and 2020-21 to study "the effect of integrated nutrient management (INM) on weed dynamics and productivity of zero tilled mustard crop." Soil at the experimental site (0-15 cm depth) was sandy loam in texture containing 63.58% sand, 20.59% silt and 15.73% clay with 7.1 pH and 0.58% organic carbon (OC) with medium in available N, P_2O_5 and K_2O contents were 228, 30.01 and 190.61 kg ha^{-1}, respectively. The average annual rainfall is about 1396 mm; of which 75% comes from south-west monsoon. During the cropping seasons revealed that maximum temperature ranged between 24-32˚C and minimum temperature prevailed between 10-19^{o}C. The experiment was conducted in Randomized complete Block Design (RCBD) with three replication comprising with eight treatments *viz*., T_1 : FYM @ 25 kg ha^{-1} + 30 kg N ha^{-1} at 30 DAS as top dressing, T_2: T_1 + straw mulch @ 5t ha^{-1}, T_3: Suphala 20:20:20 @ 150 kg ha^{-1} as basal, T_4 : T_3 + urea @ 30 kg ha^{-1} as top dressing at 30 DAS, T_5: T_4 + top dressing of MOP @ 20 kg ha^{-1} at 30 DAS, T_6: T_4 + zinc spray @ 0.25% as

$ZnSO_4$, $7H_2O$ at 40 DAS,T_7: T_4 + foliar spray of B @ 0.25% at 40DAS, T_8: T_4 + straw mulch @ 5t ha^{-1} as basal.

The variety of mustard plant used in this experiment was Keasri-5111 which is about 140-160 cm of height, 105-120 days of duration, grains are dark brown in colour, oil content generally varies between 41-42 % and having the yield potential of about 10-12 q $acre^{-1}$. The mustard variety is resistant to white rust. The seeds of mustard were line sown at the rate of 4-5 kg ha^{-1} manually with the help of hand tyne furrows were opened at 20 cm apart and seeds were dropped within them and covered with soil. In this experiment, urea, single super phosphate and muriate of potash were applied to fullfill the demand of nitrogen, phosphorus and potassium respectively and farmyard manure and straw mulch were applied as per treatment schedule. The weed density was calculated by placing the quadrat (0.25 m^{-1} area) randomly at four times and was expressed in no m^{-2}. Weed control efficiency (WCE) was calculated based on simple mathematical formula -

$$\textbf{WCE (\%)} = \frac{(WDMc - WDM_t)}{WDMc} \times 100$$

where, WDMc= Weed dry weight in control plot (g m^{-2}) and WDM_t = Weed dry weight in the treated plot (g m^{-2}). On the other hand, effect of treatments in the grain yield, straw yield and harvest index were recorded.

RESULTS AND DISCUSSION

Weed count m^{-2} is taken at 30 DAS and at harvest and weed control efficiency (Table 1) both were significant effect on integrated nutrient management practices. Irrespective of date of observations and numbers of treatments, the number of weeds were reported a diminishing trend with the age of the crop. The weed count ranges between 160 to 480 m^{-2} at 30 DAS with 66.67% variation and 48 to 128 m^{-2} at harvest with 60% variation. The highest weed count (480 and 128 m^{-2}) was recorded both in T_1 (FYM + N @ 30 kg ha^{-1} *i.e.* control) plot at 30 DAS and at harvest respectively. The lowest value of weed count (160 m^{-2}) was found in T_4 (T_3 + N @ 30 kg ha^{-1} at 30DAS) and 48 m^{-2} of weed count was recorded in T_5 (T_4 + K_2O @ 20 kg ha^{-1} at 30DAS at harvest). Yadav *et al.* (2017) reported that yellow mustard suppresses the weeds as it acts as a cover crop with age. The weed control efficiency when calculated over control plot was recorded highest (66.7%) in T_4 (T_3+ N @ 30 kg ha^{-1} at 30 DAS) and 62.5% in T_5 (T_4 + K_2O @ 20 kg ha^{-1}) at harvest. The minimum WCE was recorded in T_2 (T_1 + straw mulch @ 5t ha^{-1} + N @ 30 kg ha^{-1} at 30 DAS) *i.e*. 16.7% and 25% at both 30 DAS and at harvest.

The plant growth in terms of plant height of mustard at 30, 60, 90 DAS were recorded (Table 1) was significantly influenced by the nutrient management practices. Irrespective of date of observations and numbers of treatments, the plant height went on increasing with the age of the crop and reached its maximum till the last observation recorded at 90 DAS during investigation. Plant height of mustard ranged from 3-13 cm at 30 DAS, 81-156 cm at 60 DAS and 109- 160 cm at 90 DAS. The highest plant height was attained to 160 cm in T_4 treatment (T_3 + N @ 30 kg ha^{-1} at 30 DAS) followed by the treatment T_6 (T_4+Zn spray @ 0.25%) at 90 DAS. Kavinder *et al.* (2019) reported that the combined application of farmyard manure (15 t ha^{-1}) with 120 kg N ha^{-1} significantly improved plant height from 44.5 to 55.7 cm, under long term experimental conditions. Increase in plant height in T_4 over T_1 was recorded as 75% at 30 DAS and 48% at 60 DAS whereas, increase in plant height in T_4 over T_3 (Suphala 20:20:20 @ 150 kg ha^{-1}) S was 46% at 90 DAS.

However, rate of elongation of plant (Table 1) among different treatments varied from 2.59-4.76 cm day^{-1} at 30-60 DAS and 0.08-1.55 cm day^{-1} at 60-90 DAS. At 30-60 DAS after treatment, shoot elongation rate was significantly maximum in T_4 followed by the treatment T_6. Treatment T_1 showed the lowest elongation rate at the beginning of the crop growth but at the succeeding stage of 60-90 DAS treatment T_7 (T_4+$ZnSO_4$ @ 0.25%) observed the least elongation rate (0.08 cm day^{-1}). At 60-90 DAS, significantly maximum shoot elongation was recorded in treatment T_1 *i.e.* control followed by treatments T_2, T_5 and T_6.

The number of siliqua per plant varied from 103.2 to 137.4 with a variation of 24.8% among the treatments (Table 2). The highest number of siliqua per plant was reported in T4, at 137.4, followed by T_8, with 135.4. Singh *et al*. (2014) found that FYM (2.5 t and 5t ha^{-1}) combined with inorganic N (0, 40, 80 kg ha^{-1}) and biofertilizers increased the siliqua $plant^{-1}$ ratio. The lowest siliqua $plant^{-1}$ was recorded in T_3 treatment i.e. 103.2. Saini *et al*. (2023) reported significantly high growth and yield parameters when irrigation was scheduled at 1.0 IW/CPE and 100% RDN with mustard straw mulch @ 2 t ha^{-1}. The siliqua length ranges from 4.45 to 4.87 cm, with a 10% variance (Table 2). Under various nutrition management strategies, the highest siliqua length was recorded at T8 treatment (4.87 cm), followed by T2 treatment (4.82 cm).

Table 1: Effect of INM practices on plant height, elongation rate, weed count and weed control efficiency of mustard crop (pooled)

Treatments	Plant height (cm)			Shoot elongation rate (cm day^{-1})		Weed count m^{-2}		Weed control efficiency (%)	
	30 DAS	60DAS	90DAS	30-60 DAS	60-90 DAS	30 DAS	Harvest	30 DAS	Harvest
T_1 - FYM @ 25 kg N ha^{-1} + 30kg N ha^{-1} at 30 DAS	3	81	127	2.59	1.55	480	128	-	-
T_2 - T_1 + Straw mulch (5t ha^{-1}) + 30 kg N ha^{-1} at 30 DAS	6	110	123	3.48	0.45	400	96	16.7	25.0
T_3 - Suphala (20:20:20) @ 150 kg ha^{-1}	11	105	109	3.15	0.13	200	80	58.3	37.5
T_4 - T_3 + N @ 30 kg ha^{-1} at 30 DAS	13	156	160	4.76	0.15	160	64	66.7	50.0
T_5 - T_4 + K_2O @ 20 kg ha^{-1} at 30 DAS	6	120	134	3.82	0.44	320	48	33.3	62.5
T_6 - T_4 + Zn spray @ 0.25%	8	146	153	4.57	0.23	240	80	50.0	37.2
T_7 - T_4 + B spray @ 0.25%	9	147	149	4.57	0.08	280	96	41.7	25.6
T_8 - T_4 + Straw mulch @ 5t ha^{-1}	12	115	119	3.43	0.15	280	80	42.6	37.5
SEm (±)	**0.48**	**1.34**	**1.00**	**0.07**	**0.01**	**1.37**	**1.01**	**-**	**-**
LSD (0.05)	**1.45**	**4.07**	**3.04**	**0.22**	**0.03**	**4.17**	**3.08**	**-**	**-**

Table 2: Effect of INM practices on yield, yield components and quality attributes of zero tillage mustard (pooled)

Treatments	Siliqua $plant^{-1}$	Siliqua length (cm)	Test weight (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)	Oil content (%)	Oil yield (kg ha^{-1})
T_1 - FYM @ 25 kg N ha^{-1} + 30kg N ha^{-1} at 30 DAS	105	4.45	2.87	367	2385	13.33	40.1	146.8
T_2 - T_1 + Straw mulch @ 5t ha^{-1} + 30 kg N ha^{-1} at 30 DAS	110	4.82	2.96	506	2339	17.77	37.8	187.2
T_3 - Suphala (20:20:20) @ 150 kg ha^{-1}	103.2	4.47	2.86	555	2880	15.62	42.3	235.3
T_4 - T_3 + N @ 30 kg ha^{-1} at 30 DAS	137.4	4.46	3.40	566	3460	15.04	43.5	246.2
T_5 - T_4 + K_2O @ 20 kg ha^{-1} at 30 DAS	116.2	4.54	3.20	593	2261	21.22	43.2	257.3
T_6 - T_4 + Zn spray @ 0.25%	117.2	4.69	3.03	850	3443	19.79	42.1	360.4
T_7 - T_4 + B spray @ 0.25%	132.2	4.68	3.00	858	3417	20.36	40.6	348.3
T_8 - T_4 + Straw mulch @ 5t ha^{-1}	135.4	4.87	3.02	770	3296	18.93	40.3	310.3
SEm (±)	**1.29**	**0.15**	**0.15**	**3.25**	**10.20**	**0.07**	**0.77**	**1.39**
LSD (0.05)	**3.93**	**0.45**	**0.45**	**9.86**	**30.94**	**0.20**	**2.33**	**4.23**

Jakhar *et al*. (2018) reported similar findings, where main plot treatments consisted of four moisture conservation practices adopted in kharif season crop, viz. ridges and furrows (RF), RF + crop residue (CR) 4 t ha^{-1}, RF + CR 2 t ha^{-1} + vesicular arbuscular mycorrhiza (VAM), and flat sowing (FS), and in sub plots;five zero tillage management techniques, viz. zero tillage (ZT), ZT + seed priming, ZT + CR 4 t ha^{-1}, ZT + CR 2 t ha^{-1} + Hydrogel, and conventio Sowing in furrows with RF + CR 4 tonnes/ha produced the greatest values for seeds $siliqua^{-1}$ and siliqua length at 13.16 and 4.17 cm, as well as seed yield (2.12 t ha^{-1}) and stover yield (7.46 t ha^{-1}).

The test weight of siliqua (Table 2) ranges from 2.86 to 3.4, a variation of 15.88%. T4 treatment had the highest test weight of 3.4 g, followed by T5 treatment) with 3.2 g. The lowest test weight (2.86 g) was discovered in T3 treatment. The seed yield (Table 2) ranges from 367 kg/ha to 858 kg/ha, a variation of 57.22%. The lowest seed production (367 kg ha^{-1}) was obtained with treatment T1. Treatment T7 had the highest seed yield (858 kg ha^{-1}), followed by treatment T6 (850 kg ha^{-1}). The foliar application of Boron at 0.25% in treatment T7 increased the yield by 35.31% above treatment T3 (Suphala 20:20:20). Mandal and Sinha (2004) supported this finding. They worked with Indian mustard and found that using an optimal combination of NPK, FYM, Borax, and ZnSO4 resulted in greater seed output. According to Singh *et al*. (2021), the highest seed yield (3567 kg ha-1) was obtained with the application of RDF in conjunction with the first spray of 1% urea phosphate, the second spray of 2.0% urea phosphate with Sulphate of Potash (SOP), and the third spray of 2.0% SOP, which was 27.3% higher than yields obtained with RDF alone.

The stover yield ranges from 2339 to 3460 kg ha^{-1}, representing a 32.57% variation. Among the treatments, T_4 produced the highest stover yield (3460 kg ha^{-1}), followed by T6 treatment, which produced 3443 kg ha^{-1}. As a result, T4 treatment produced a 31.06% increase in stover production compared to the control, T1.

Among the various treatments, T_5 treatment (Table 2) produced the highest harvest index of 21.22%, followed by T_7 (20.36%), and the control (T_1) treatment produced the lowest harvest index of 13.33%. As a result, the harvest index of T5 treatment increased by 37.18% above the control. A satisfactory harvest index of 19.79% was also reported with treatment T_6, which included a foliar application of ZnSO4 @ 0.25% with Suphala and N @ 30 kg ha^{-1} at 30 DAS.

Table 3: Effect of integrated nutrient management in available soil nutrient status on zero-tillage mustard crop (pooled)

Treatments	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
T_1 - FYM @ 25 kg N ha^{-1} + 30kg N ha^{-1} at 30 DAS	100.31	9.12	180.02
T_2 - T_1 + Straw mulch (5t ha^{-1}) + 30 kg N ha^{-1} at 30 DAS	120.44	8.86	212.32
T_3 - Suphala (20:20:20) @ 150 kg ha^{-1}	101.40	6.77	171.6
T_4 - T_3 + N @ 30 kg ha^{-1} at 30 DAS	100.35	9.16	200.01
T_5 - T_4 + K_2O @ 20 kg ha^{-1} at 30 DAS	115.60	9.01	201.2
T_6 - T_4 + Zn spray @ 0.25%	137.98	9.17	191.12
T_7 - T_4 + B spray @ 0.25%	110.80	9.18	195.6
T_8 - T_4 + Straw mulch @ 5t ha^{-1}	125.44	10.13	213.25
SEm (±)	1.22	0.02	1.33
LSD (0.05)	3.72	0.075	4.03

The oil content ranges from 37.3% to 43.5%, representing a 14.25% variance. Among the various treatments, T_4 has the highest oil content (43.5%), followed by T_5 treatment. The lowest oil content (37.3%) is achieved at T_2 treatment i.e. (FYM + N at 30 kg ha^{-1} at 30 DAS + straw mulch @ 5 t ha^{-1}).

The oil yield ranges from 146.8 to 360.4 kg ha^{-1}, representing a 59.15% spread.T6 treatment produces the highest oil (360.4 kg ha^{-1}), followed by T7 (348.35 kg ha^{-1}). Malhi *et al*. (2006) also observed that applying Zn and B greatly boosted oil yields. T_1 treatment produces the lowest oil output (146.8 kg ha^{-1}).

After harvesting the mustard crop, accessible soil nitrogen, phosphorus, and potassium levels varied dramatically depending on nutrient management strategies (Table 3). The available nitrogen in the soil ranged from 100.31 to 137.98 kg ha^{-1}, with a 27.30% variation. The plot fertilised with T_6 treatment had the highest nitrogen availability (137.98 kg ha^{-1}), followed by the plot fertilised T_8. The lowest available nitrogen (100.35 kg ha^{-1}) was found in T4 treatment because the plant used the native soil nutrients. Phosphorus availability in the soil ranged from 6.77 to 10.13 kg ha^{-1}, representing a 33.16% variance. The maximum accessible phosphorus was found in the application T_8, followed by T_7 treatment, while the lowest available phosphorus (6.77 kg ha^{-1}) was reported in T_3 treatment. The accessible potassium in the soil ranged between 171.6 and 213.25 kg ha^{-1}, with a 20% variance. The greatest available potassium (213.25 kg ha^{-1})

was obtained by applying T8 treatment, followed by T_1 + Straw mulch (5 t ha^{-1}) + 30 kg N ha^{-1} at 30 DAS, while the lowest data (171.6 kg ha^{-1}) was obtained in T_3 treatment.

CONCLUSION

Different treatments with Suphala and other nutrients were found to be more effective in boosting the growth and yield of the hybrid mustard variety (Kesari-5111). The weed count is found to be the lowest, 160, at 30 DAS when Suphala, N is applied, and 48 at harvest when Suphala, N and K_2O are applied together. Again, straw mulch application has been proven to be helpful in weed control, with a lower weed count than other treatments that did not employ straw mulches. Based on the observations, it is possible to conclude that hybrid mustard can be grown at zero tillage with the application of Suphala + N @ 30 kg/ha + B @ 0.25% may be recommended for new alluvial soils of West Bengal.

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