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EFFECT OF NITROGEN-PHOSPHORUS AND IRRIGATION SCHEDULES ON THE GROWTH AND YIELD OF MUSTARD (BRASSICA JUNCEA L.)

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ABSTRACT

To investigate the impact of nitrogen and phosphorus, as well as different irrigation schedules, on the growth and yield of the Mehran Raya variety of mustard, the results showed that the F_{3} = 120–60 kg/ha produced population plant (31.78 m^2), height of plant (181.09 cm), branch plant^{-1} (9.24), pods/plant (832.87) seeds pod^{-1} (15.26), seed index (1000 seeds wt. 17.11 g), and seed yield (2407.67 kg ha^{-1}). While the F1 (control) results showed minimum plant population of 8.11 m2, height of plant (126.98cm), branch plant (4.92), pods plant (471.49) seeds pod (5.07), seed index (1000 seeds wt. 14.44 g), and seed yield (1279.22kg ha^{-1}). In case of irrigation, maximum plant population (24.22 m^2), the height of plant (165.93 cm), branches plant-1 (8.09), pods plant-1 (565.22) seeds pod^{-1} (12.04), seed index (1000 seeds wt. 17.11 g), and seed yield (1955.11 kg ha^{-1}). Whereas the minimum plant population (17.11 m^2), height of plant (148.80 cm), branches plant-1 (6.22), pods plant-1 (637.04), seeds pod^{-1} (8.74), seed index (1000 seeds wt. 15.56 g), and seed yield (1579.67 kg ha^{-1}) were recorded in one irrigation. Based on the results found, it can be concluded that the balanced fertilization and irrigation scheduling were higher than the alone application of treatment due to the synergetic effect of NP with irrigation by mustard in terms of growth and seed yield. It was determined that despite the consequences of the variation in the values of the different growth yield traits of the mustard crop, the harvest was markedly higher (2407.6 kg ha^{-1}) when the crop was given NP at 120–60 kg ha^{-1}.

Keywords: Mustard, Nitrogen-Phosphorus, Irrigation-Schedules

INTRODUCTION

Mustard, scientifically known as Brassica Juncea L., holds a notable position among oilseed crops globally. It stands as the third-largest source of vegetable oils, trailing behind soybean and palm. In terms of oilseed protein production, it claims the second position worldwide, following soybean, as per the USDA data from 2012. The collective output of rapeseed mustard (*Brassica juncea* L.) reached 62.45 million metric tons from a cultivated area spanning 33.64 million hectares, with a combined yield averaging 18.56 quintals per hectare, according to FAO figures from 2011.

The Pakistani economy is heavily reliant on agricultural production, with approximately 80% of its edible oil needs being met through imports in 2012–13. This is due to local edible oil production only accounting for 20% of the domestic demand during that period. In 2012–13, the total consumption of edible oil in the country amounted to 3.069 million tons. Of this, the domestic edible oil production was estimated at 0.606 million tonnes, while a significant 2.502 million tonnes were imported. The import bill for edible oil in 2012–13 reached a substantial PR of 241.936 billion. Moving to the following year, in 2013-14, in the period from July to March, Pakistan imported approximately 1.719 million tonnes of edible oil, valued at Rs. 148.633 billion. During the same period, local edible oil production remained at 0.606 million tonnes, and the overall availability of edible oil from various sources was approximately 2.325 million tonnes in 2013–14, as per the Government of Pakistan's report from 2008.

Oilseed crops play a crucial role in the Indian agricultural economy, accounting for 14% of the nation's total cropped area and contributing to 10% of the value of agricultural products. The significant surge in the prices of edible oils in recent years has heightened the importance of oilseed cultivation. In our nation, within the category of oilseed crops, rapeseed and mustard hold a preeminent position. They are remarkably versatile and exhibit a notable capacity to thrive under diverse agro-climatic conditions, owing to their wide adaptability and considerable production potential. Rapeseed and mustard encompass various oilseed crops that belong to the Brassicaceae family and the Brassica genus. This crop is part of the Rabi season and thrives in the northern and north-western regions of India, particularly on sandy topsoil, loamy sand, and medium-dark soils. The use of phosphorus-solubilizing microorganisms can aid in reducing the need for synthetic fertilizers. These resources are cost-effective, environmentally friendly, and sustainable. Given the aforementioned considerations, a study was conducted to explore the integrated management of phosphorus in mustard, as documented by Patel *et al*. in 2019. Nitrogen plays a fundamental role in various cellular and functional processes, including osmotic adjustments, energy transfer, detoxification of reactive oxygen species, protein synthesis, regulation of stomata, and phloem transport, and serves as a crucial indicator of salt tolerance in plants. Flowers adapted to alkaline soils with higher pH levels predominantly utilize nitrogen in the form of nitrate. Plants employ two nitrate transport systems that work synergistically to absorb nitrate from the soil solution and transport it throughout the entire plant, as discussed in the study by Gulzar *et al*. in 2019. Phosphorus, another essential component, plays a critical role in maintaining the structural and functional integrity of membranes, modifying cell walls, and regulating ion balance. After nitrogen, phosphorus is recognized as the second most crucial nutrient for plants. It exists in the soil either as organic salts or integrated into organic compounds. Although agricultural soils contain a substantial amount of these phosphorus compounds, as noted by Miller *et al*. in 2010, the majority of them are in insoluble form.

To tackle this challenge, soluble phosphorus in the form of phosphate fertilizers is employed. Nevertheless, these fertilizers have constraints, as they can rapidly become immobilized, transforming into insoluble forms upon entering the soil due to reactions with aluminium and iron deposits. The utilization efficiency of accessible phosphorus rarely surpasses 31% because of its fixation in the soil, as noted by Sharma *et al*. in 2013. Moreover, a substantial portion is lost through excessive leaching and filtration, resulting in only 10–20% being available for plant utilization, as outlined by Sashidhar and Podile in 2009.

Dependence on phosphorus sourced from phosphate rock in phosphate fertilizers raises concerns due to the non-renewable nature of phosphate rock. According to Cordell *et al*. (2009), current global reserves could be exhausted within 50–100 years. Therefore, exploring alternative agricultural practices that priorities nutrient conservation is of paramount importance. Nitrogen and phosphorus can easily be displaced from their binding pathways by various salts and chlorides, potentially leading to significant disruptions in the beneficial functions associated with these essential nutrients. Maintaining adequate levels of phosphorus and nitrogen in saline soils is crucial for mitigating the adverse effects of high ion toxicity, especially in glycophytes, which are more susceptible to sodium damage. To counteract the negative impact of high salinity, the addition of Ca2+ as a remedial agent to the growth medium can be essential, impacting the root-to-shoot ratio. Both nitrogen and phosphorus are essential nutrients for ecosystem structure, processes, and functionality since their availability limits plant biomass production and growth (Hu and Schmidhalter, 2006). Furthermore, in Arabidopsis plant species, it has been demonstrated that varying nutrient levels can influence both root length and growth adaptability (Gruber *et al*., 2013).

MATERIAL AND METHODS

During 2019-20, the trail was performed at a student's experimental farm at the Department of Agronomy, Faculty of Crop Production. The experiment was set up in a randomized full block configuration of three replications (RCBD). The below are the specifics of the procedure.

Experiment design: (RCBD)
Replications: Three
Net plot size: 3 m x4 m(12m-2)
Variety: Mehran Raya
Factor-A: NP levels (NP) = 03 (NP1= Control, F2= 100-40 kg ha-1, F3= 120-60 kg ha-1)
Factor-B: (I) Irrigations = 03 (I1= One Irrigations, I2=Two Irrigations, I3=Three Irrigations)
Treatment Combination:
T1= F1 I1, T2= F1I2, T3= F1 I3, T4= F2 I1, T5= F2 I2,
T6= F2 I3, T7= F3 I1, T8= F3 I2, T9= F3 I3.

Observations were recorded:

1. Population plant (m2)
2. Height of plant (cm)
3. Branches/plant
4. Pods/plant
5. Seeds pod-1
6. Seed index (1000seeds weight, g)
7. Yield seed kg ha^{-1}

RESULTS

The experiment took place at the Student's Farm within the Department of Agronomy at SAU Tandojam during the 2019–2020 period. To determine the effects of N and P, as well as irrigation scheduling, on mustard growth and yield. Three levels of fertilisers, identified as NP-F1 (control), F2 (100–40 kg/ha), and F3 (120–60 kg/ha), were studied alongside three irrigation schemes, I1 (1 irrigation), I2 (2 irrigations), and I3 (3 irrigations), to evaluate their independent and combined impacts on diverse agronomic traits. These traits encompass plant population (m2), plant height (cm), branches per plant, pods per plant, seeds per pod, and seed index (1000 seed weight, g). The statistically analyzed results were presented in Tables 1–7, as well as a transition overview (Appendix- I–VI).

Population plant (m2): It can be seen from the findings (Table 1) that gathering gather fertilizer per NP@ at 120–60 kg ha-1 resulted in a standard population plant of 31.7 m2, while decreasing fertilizer values, i.e., NP @ 100–40 kg ha-1, resulted in a standard population plant of 20.6 m2. In the control treatment, where no fertilizer was added, the lowest population plant of 8.1 m2 was visible. In terms of irrigation levels, plots earning three irrigations had the largest population of 24.2. When the crop was definite two irrigations, the population plant decreased to 19.2. On the other side, the plots with the lowest population plant (17.1) needed just one irrigation. The collaborative impact revealed that the transfers (NP @ 120–60 kg ha-1 x 3 irrigation) resulted in the highest possible population plant (35.3), as well as the lowest possible population plant (4.6). It was also observed that increasing the amount of mineral fertilizers and the number of irrigation points had a beneficial effect on the mustard population plant.

Table 1. Population plant (m^2) of mustard as affected by fertilizer and irrigation

Irrigation/NP	F_1	F_2	F_3	Mean
I_1	4.67	17.33	29.33	17.11 **C**
I_2	7.33	19.67	30.67	19.22 **B**
I_3	12.33	25.00	35.33	24.22 **A**
Mean	8.11 **C**	20.67 **B**	31.78 **A**	

	Fertilizer	Irrigation	Frt x irri
S.E	0.9681	0.9681	1.6768
LSD=0.05%	2.0523	2.0523	3.5547

Height of plant (cm): **t**he crop treated with NP at a rate of 120–60 kg/ha attained an average maximum plant height of 181.0 cm, whereas reducing the fertilizer rates to NP at 100–40 kg/ha resulted in an average plant height of 164.9 cm. The control plot, which obtained no NP fertilizer, had the deepest plant height of 126.9 cm. In terms of irrigation quantities, plots receiving three irrigations had a concentrated height of 165.9 cm, while plots receiving two irrigations had a height of 158.2 cm. Despite this, the plot with one irrigation had the shortest plant height of 148.8 cm. The interactive impact revealed that the partnership (NP @ 120–60 kg ha-^{1} x three irrigations) resulted in a concentrated height of 190.2 cm, while the relationship (one irrigation x control plot) showed the smallest height of the plant, 110.6 cm. It was also reported that the increased use of NP fertilizers and the number of irrigation systems had a positive impact on the height of the mustard plant.

Table 2. Height of plant (cm) of mustard as affected by fertilizer and irrigation

Irrigation/NP	F_1	F_2	F_3	Mean
I_1	110.67	162.33	173.40	148.80**C**
I_2	130.70	164.47	179.67	158.28 **B**
I_3	139.57	168.03	190.20	165.93 **A**
Mean	126.98 **C**	164.94 **B**	181.09 **A**	

	Fertilizer	Irrigation	Frt x irri
S.E	2.1798	2.1798	3.7755
LSD=0.05%	4.6210	4.6210	8.0038

Branches/plant: It is evident from the findings (Table 3) that the crop fertilized with NP at 120–60 kg ha-^{1} resulted in the largest number of branches per plant (9.2 on average), while fertilizer values reduced to NP @ 100–40 kg ha-^{1} resulted in typical branches per plant. 7.7. In a transfer plot with no NP fertilizer, the deepest number of branches per plant was observed. In terms of irrigation levels, plots receiving three irrigations had the highest amount of kindling plant-^{1} (8.0), whereas plots receiving two irrigations had the lowest amount of kindling plant-^{1} (7.5). On the other hand, the plot with one irrigation yielded the lowest number of branches per plant. 6.2. The interacting impact revealed that the relationship (NP @ 120–60 kg ha-^{1} x three irrigations) culminated in the highest number of branches per plant (9.5) and the minimal number of branches per plant (3.3) at the interface (one irrigation x control plot) with no NP. It was previously understood that increasing the amount of NP fertilizers in addition to the quantity of irrigation had a beneficial impact on mustard branch plant 1.

Table 3. Branches/plant of mustard as affected by fertilizer and irrigation

Irrigation/NP	F_1	F_2	F_3	Mean
I_1	3.33	6.27	9.07	6.22 **B**
I_2	5.53	8.07	9.13	7.58 **A**
I_3	5.90	8.83	9.53	8.09 **A**
Mean	4.92 **C**	7.72 **B**	9.24 **A**	

	Fertilizer	Irrigation	Frt x irri
S.S S.E	0.4541	0.4541	0.7865
L LSD=0.05%	0.9626	0.9626	1.6673

Pods/plant: It can be shown from the results (Table 4) that the crop manured with NP at 120–60 kg ha-[1] produces the highest amount of pods per plant (832.8 on average), while the crop manured with NP @ 100–40 kg ha-[1] produces the usual pod plant (567.8. In the resistor map, where no NP fertilizer was added, the lowest amount of pods (plant 471.4) was prominent. In terms of irrigation levels, plots receiving three irrigations had the maximum number of pods per plant (669.8), whereas plots receiving two irrigations had the lowest number of pods per plant (637.0). Despite this, the plot with the lowest number of pods per plant (669.8) was experimentally assigned one irrigation. The interactive impact revealed that the touch (NP @ 120–60 kg ha-[1] x three irrigations) produced the highest number of pods per plant (975.8), while the partnership (one irrigation x control plot) produced the lowest number of pods per plant (302.1). It was also reported that an improvement in the volume of NP fertilizers and irrigation water had a positive effect on mustard pods and plants

Table 4. Pods/plant of mustard as affected by fertilizer and irrigation

Irrigation/NP	F_1	F_2	F_3	Mean
I_1	302.13	633.13	975.87	637.04 **AB**
I_2	485.20	492.73	717.73	565.22 **B**
I_3	627.13	577.53	805.00	669.89 **A**
Mean	471.49 **C**	567.80 **B**	832.87 **A**	

	Fertilizer	Irrigation	Frt xirri
S.E	45.369	45.369	78.582
LSD=0.05%	96.179	96.179	166.59

Seeds pod^{-1}: It can be seen from the findings (Table 5) that the plant fertilized with NP @ 120–40 kg ha-1 produced 15.2 seeds pod-1 on average, while the plant fertilized with NP @ 100–20 kg ha-1 produced 10.2 seeds pod-1 on average. The spore pod-15.0 with the lowest amount of spores was prevalent in the control map, where no NP fertilizer was added. In terms of irrigation volumes, plots receiving three irrigations had a concentrated amount of seeds per pod of 12.0, while plots receiving two irrigations had a number of seeds pod-1 of 9.8. On the other side, starting the plot with one irrigation, the minimum number of seeds pod-1 8.7 was observed. In the scenario where no NP (nitrogen and phosphorus) was applied at the interface (one irrigation x control plot), the synergistic effect was evident. Specifically, the interaction between NP at 120–60 kg/ha and three irrigation events led to the highest number of seeds per pod, reaching 16.3, while the lowest number recorded was 3.9 seeds per pod. It was historically established that growing the volume of NP fertilizers and the number of irrigation points helped regulate mustard seed pod-1.

Table 5. Seeds pod^{-1} of mustard as affected by fertilizer and irrigation

Irrigation/NP	F_1	F_2	F_3	Mean
I_1	3.90	8.20	14.13	8.74**C**
I_2	4.67	9.50	15.27	9.81**B**
I_3	6.63	13.13	16.37	12.04**A**
Mean	5.07**C**	10.28**B**	15.26**A**	

	Fertilizer	Irrigation	Frt x irri
S.E	0.3098	0.3098	0.5366
LSD=0.05%	0.6568	0.6568	1.1376

Seed index (1000-seed weight, g): The condition is obvious from the fact that plots fertilized with the maximum NP sum of 120–40 kg ha-1 developed the highest seed file value of 17.8 g, accompanied by a 17.1 g ordinary seed index worth in plots fertilized with NP @ 100–20 kg ha-1. In a process plot without NP, an absolute seed index value of 14.4 g was observed. In terms of irrigation, plots receiving three irrigations had the maximum seed index value of 17.1 g, while plots receiving two irrigations had an average seed index value of 16.6 g. The lowest seed index value of 15.5 g, on the other hand, was realistic in plots with just one irrigation. The contact (NP @ 120–40 x three irrigations) culminated in the maximum seed index value of 20.6 g and the lowest seed index value of 13.3 g in the interface, according to the dealings readings (control plot x one irrigation). The optional outcome was that decreasing NP compost rates had a strong unwanted effect on the mustard seed index value.

Table 6. Seed index (1000-seed wt., g) of mustard as affected by fertilizer and irrigation

Irrigation/NP	F_1	F_2	F_3	Mean
I_1	13.33	19.33	14.00	15.56 **B**
I_2	13.33	16.00	20.67	16.67 **AB**
I_3	16.67	18.00	16.67	17.11 **A**
Mean	14.44 **B**	17.78 **A**	17.11 **A**	

	Fertilizer	Irrigation	Frt x irri
S.E	0.6573	0.6573	1.1386
LSD=0.05%	1.3935	1.3935	2.4136

Yield seed kg ha^{-1}: The top NP doses of 120–40 kg ha-1 culminated in the most popular highest yield seed of 1955.1 kg ha-1, as determined by the grain yield of 1790.5 kg ha-1 realized from the design set NP @ 100–20 kg ha-1. The monitor with no NP applied had a maximum yield of 1579.6 kg ha-1. In terms of irrigation rankings, the plans obtaining three irrigations provided the highest yield seed of 2407.6 kg/ha, accompanied by two irrigations and ordinary yield seeds of 1638.4 kg ha-1. However, the plots granted one irrigation yielded a total of 1279.2 kg ha-1 of bottom kernels. Dealings (Np @ 120–40 kg ha-1 x three irrigations) culminated in main grain yields of 2708.3 kg ha-1pluseast kernels plus east kernels yields of 1116.0 kg ha-1, according to the interface readings. It was shown that lowering the NP fertilizer dosage had a significant negative impact on the seed crop g/ha. Furthermore, simple opposing properties of water worry on mustard were noted, and reducing the amount of irrigations resulted in crop refuse.

Table 7. Yield seed (kg ha^{-1}) of mustard as affected by fertilizer and irrigation

Irrigation/NP	F_1	F_2	F_3	Mean
I_1	1116.00	1524.67	2098.33	1579.67 **C**
I_2	1309.67	1645.67	2416.33	1790.56 **B**
1_3	1412.00	1745.00	2708.33	1955.11 **A**
Mean	1279.22 **C**	1638.44 **B**	2407.67 **A**	

	Fertilizer	Irrigation	Frt x irri
S.E	24.269	24.269	42.035
LSD=0.05%	51.448	51.448	89.111

DISCUSSION

Use of NP composts at suitable measures, mainly N and P, is indispensable to reaching preferred harvests in mustard. Kumar *et al*. (2017) found that the height of a plant increases with the application of N levels at every observation. Minimum heights of plant 22.24, 100.56, and 157.53 cm were recorded in T1 (control) at all stages, respectively. Nitrogen and sulphur application induced significant growth in the growth and produce of Indian Mustard N claim active to 120 kg ha-1 logged significant rise in plan height, quantity of primary, amount of leaves and secondary branches, dry matter buildup at completely the growth phases and yield seed over the following level of nitrogen, which was at par with 80 kg Nitrogen ha-1 over the control and 40 kg N ha1. Nikhil *et al*. (2018). The maximum plant tallness, dry substance accumulation, and number of branches were experimental with 160 kg N ha-1despite the fact that direct plants were noted under switch plots at all stages of crop development (Raghuvanshi *et al*., 2018). The growth and yield attributes of mustard were meaningfully affected by different stages of phosphorus. Use of phosphorus @ 60 kg P2O5 per ha resulted in suggestively higher crop elevation, number of branches/plant, dry matter gathering plant-1, amount of silique plant-1, number of grain siliquae-1, and test mass of mustard over control and by par with 40 kg P2O5 ha-1Potdar*et al*. (2019). The accelerated growth of the plant height, as documented by Bhari *et al*. (2000) and Sharma *et al*. (2007), may be attributed to the conversion of mineral nitrogen, sulfur, and synthesized carbohydrates from the plant's green tissues into amino acids and subsequently into proteins, facilitating faster growth. The rise in seed yield was linked to an increase in all yield-contributing factors. A sufficient nitrogen supply promoted superior growth and development of the crop plants, facilitated enhanced nutrient absorption, and consequently led to a significant increase in yield characteristics. Similar findings were also documented by Sharma (2008).

CONCLUSION

It was determined that despite the significance of the variation in the values of the different progress yield traits of the mustard crop, the grain yield was obviously developed (2407.6 kg ha-1) when the gather was given 120–40 kg ha-1.

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