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# Influence of Clomazone on Weeds, Macronutrients Uptake, Yield of Transplanted Rice Crop in Lowland of Egypt

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**ABSTRACT**

An experiment under field conditions was carried out in the lowland at Wadi Al-Mollak, East Delta, Egypt during the 2019 season to control the rice weeds by clomazone herbicide concerning nutrient uptake as well as growth and yield of the transplanted rice. The experimental site soils were clay to clay loam in texture, medium in available nitrogen, and high in both available phosphorus and potassium. Seven treated plots with three replications of the experiment were conducted in different periods at twenty, forty, and sixty days after transplanting (DAT). Pre-emergence herbicide clomazone at different doses of 150, 200, 250, and 300 g/ha was compared with 0.75 kg/ha of pretilachlor, physical weed control (hand weeding twice), and untreated plot control. Six species of different weeds were identified throughout the growth stages of the rice crop. They are grasses (*Echinochloa crus-galli* and *Echinochloa colonum)*, sledges (*Cyperus difformis* and *Scirpus maritimus)*, and broad-leaved weeds (*Eclipta alba*, and *Ammania baccifera)*. Grasses were the predominant weeds in the early stages, whereas in the latter stages clomazone @ 300 g/ha and broad-leaved weeds were predominant. The dose of 300 g/ha of clomazone resulted in lower values of macronutrients depletion by studied weeds and the highest uptake by rice crop. Further, these doses gave the highest values for plant height, crop dry matter production. The dose of clomazone @ 300 g/ha verified the highest grain yield of 5690 kg/ha with respect to 5613 kg/ha in $T_3$ of clomazone @ 250 g/ha, 5665 kg/ha in $T_6$-physical method by hand weeding twice, and 5611 kg/ha in pretilachlor. Among the clomazone treatments, the results may be concluded that the doses of clomazone @ 300 and 250 g/ha are the optimal rates for effective management of weeds in the transplanted rice ecosystem. The research work recommended that the lower rates of herbicide treatment were not enough to curtail early weed competition, and therefore the dose of clomazone @ 250 g/ha incorporating hand-weeding are the safer and operative methods for controlling the tested weeds, enhancing nutrient uptake for optimum growth of rice plants, and obtaining the higher grain and straw yields of rice crop.

## INTRODUCTION

*Oryza sativa* L. is mainly cultivated as a cereal food crop in Egypt. It feeds over 50% of the people population worldwide (López-Piňeiro *et al*., 2022). The nutritional value of rice is very high that containing 8.1% gluten, 2.2% fibers, 77.1% of carbohydrates, and 349 calories (Singh and Singh, 2017). Demand for rice is expected to grow at a faster pace due to the galloping


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population growth, steadily dwindling croplands, and an increasing threat of famine (Cutti *et al.*, 2021). However, there is no scope for increasing rice production through an increase in rice area, and hence, increasing the productivity of rice through proper crop management is of great concern (Cutti *et al.*, 2021). In Egypt, the cultivated lands with transplanted rice were reduced to occupy an area of less than a million Faddan because of its high consumption of irrigation water under the limited water resources of Egypt (Elbasiouny and Elbehiry, 2020). The infestation monitoring in rice fields is vital for precision farming and optimal growth to get good grain quality and high yield while reducing negative impacts on the ecosystem (Krishna *et al.*, 2019).

Among the production factors, the infestation of rice by harmful weeds is a hazardous biotic constraint that reduces the yield and productivity of rice by 42% under transplanted conditions (López-Piňeiro *et al*., 2022). It also deprives the crop uptake by 45% of added nutrients along with 35-45% of soil moisture. In addition, it adds to the increased cost of labor and reduces the quality and quantity of produce. Approximately 60% of weeds arise in the field 10-30 days after transplanting (Cutti *et al.*, 2021). About 50% yield is decreased because of weeds in the transplanted rice ecosystem (Krishna *et al.*, 2019). Managing the weeds in rice fields is considered a vital key for generating higher yields as weeds are the silent, malignant and massive force that reduces the yield substantially (Veeraputhiran and Balasubramanian, 2013). Hence, weed competition should be prevented at the early critical growth stages especially, tillering stage to obtain a weed-free ecosystem of rice for successful rice production (Cutti *et al.*, 2021).

Various grasses in the ecosystem of rice may be managed either by manual weeding or applying the herbicides in pre-emergence and post-emergence. Manual weeding increases the input costs of the laborer. Furthermore, the shortage of these laborers at the critical time of developmental stages of cultivated rice leads to reducing the quantity and quality of the gains, and therefore searching for alternative approaches is highly needed. Accordingly, specific herbicides can be applied for controlling *Cyperus* before rice transplanting to reduce these weeds in the field and facilitate land preparation. The chemical method was the most effective than the physical hand weeding (López-Piňeiro *et al*., 2022). Thiobencarb, pretilachlor, and anilofos are significant pre-emergence herbicides for weed management in the rice ecosystem under saturated conditions. A combination of pre-emergence and post-emergence herbicides may be utilized to manage weeds in rice fields. In addition, the sequential application of herbicides may be used to manage these grasses in the rice ecosystem (Manisankar *et al.*, 2021; López-Piňeiro *et al*., 2022).

Clomazone is a new selective herbicide that can manage broad-leaved weeds and various grasses in a transplanted rice environment. It can be absorbed by roots, emerging shoots, and leaf tissue (López-Piňeiro *et al*., 2022). The synthesis of plastoquinone, carotenoids, chlorophyll, and gibberellin can be inhibited by clomazone in the susceptible species of rice (Manisankar *et al.*, 2020). In this context, bioefficacy studies gain momentum, and the studies on bioefficacy of clomazone are limited. Hence, the present work has been undertaken under flooding conditions of rice to investigate: (1) the effectiveness of clomazone at diverse dosages in controlling different weeds at development stages, (2) the impacts of weed control treatments on the uptake of macronutrients by crop and their depletion by competed weeds at developmental and growth stages, and (3) the effects of weed control treatments on grain and straw yields of studied rice crop.

## MATERIALS AND METHODS

An experiment was performed on the rice crop under flooded field conditions in 2019 to find out the effective dose of clomazone against rice weeds (broad-leaved, sedges, and grasses) regarding nutrient uptake and crop yield.

**Field Experiment Site:**

In general, the field experiment was conducted at Wadi Al-Mollak, east of Nile Delta, located on Suez Canal west, Egypt (Fig. 1). Wadi Al-Mollak is situated between the longitudes of 31° 39' to 32° 1' E and the latitudes of 30° 14′ to 30° 34' N (Fig. 1). It extends from the southeastern part of the mountains to the east of the Nile Delta in the north. The site is characterized by an arid to a hyper-arid climate with dry summers and wet winters (Egyptian Meteorological Authority, 2020). The soil temperature at Wadi Al-Mollak differs annually from 21 to 37°C with an evaporation rate of 8-17mm/day. The annual rainfall varies between 21 and 39 mm with a relative humidity of 45-57% (Egyptian Meteorological Authority, 2020). The current field experiment lies between latitudes of 30° 31′ 3″ to 30° 31' 55″ N and longitudes of 31° 44' 37″ to 31° 45' 10″ E (**Fig. 1**).

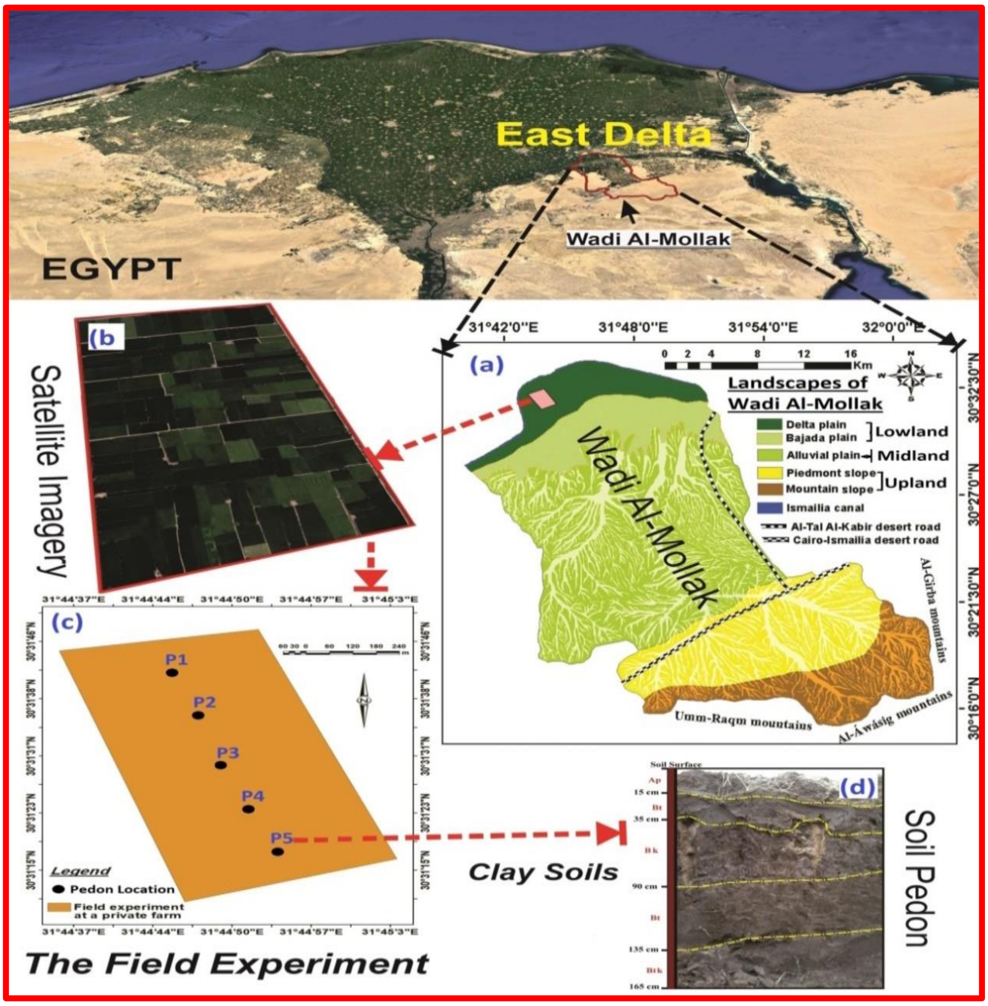


**Fig. 1.** Site location of the current field experiment in the clay soils at lowland position of Wadi Al-Mollak, East Delta, Egypt. **(a)** Landscapes of Wadi Al-Mollak, **(b)** Satellite imagery of selected farm for doing the field experiment, **(c)** Soil pedons location across the farm field, and **(d)** A horizon sequence model of soil pedon as one of the five representative soil pedons

**Soil Analyses:**

During preparing the soil for planting, the soil salinity and alkalinity of the selected farm were removed from the rooting zone of transplanted rice by following the standard procedures of water leaching and gypsum requirements (Elwan, 2018). The irrigation water was sourced from River Nile through Ismailia Canal. Accordingly, five pedons were distributed across the studied private farm (Fig. 1b). The soil samples of selected pedons were collected from the private farm where the field experiment was conducted as shown in Figure 1. Soils were sampled by genetic horizon for each soil pedon (Soil Science Division Staff, 2017). Collected soils were prepared for their physicochemical and fertility characteristics in the laboratory. The physical characteristics included gravel content, soil texture, available water, and bulk density meanwhile the chemical properties were electrical conductivity ($EC_e$), pH, total nitrogen, organic matter, CEC, gypsum, and $CaCO_3$ content. The macronutrients and soil fertility status were available and total concentrations of nitrogen, potassium, and phosphorus. The procedures of Pansu and Gautheyrou (2006) were used to measure the USDA particle size classes and identify soil texture by the pipette scheme. The bulk density (ρb) of soil was examined following the methods of Grossman and Reinsch (2002). Electrical conductivity of soil (ECe), soil reaction (pH), $CaCO_3$ (%), available water level, and cation exchange capacity (CEC) were accurately estimated (Jackson, 1973; Soil Survey Staff, 2014). The differential water loss method was used to determine the percentage of soil gypsum (Artieda *et al.*, 2006). Organic carbon content in studied soil was analyzed as per the procedures of Soil Survey Laboratory Staff (2004). The dry combustion method at 900°C was used to determine total nitrogen concentration in soil (Nelson and Sommers, 1996). The Kjeldahl technique was utilized to measure the available nitrogen level in soil (FAO, 1970). Available phosphorus and potassium contents were measured by using standard approaches (Soltanpour and Schwab, 1977). The weighted mean was calculated for the estimated characteristics values of subsequent layers for each pedon (Elwan, 2013).

**Experimental Design:**

Giza 177 variety of rice, with a short duration of 125 days, was cultivated in the clay soils of Wadi Al-Mollak during the 2019 season. The experiments were designed using randomized block design (RBD). The field treatments included four doses of clomazone compared to pretilachlor as well as manual weeding by hand and unweeded unit control. The treated rice plots were designed as shown in Table 1.

**Table 1.** The details of different treatments in the field are followed in the current work.

| Treatment | The management method | Dosage per hectare |
|---|---|---|
| $T_1$ | Clomazone 50 EC | 150 (g/ha) |
| $T_2$ | Clomazone 50 EC | 200 (g/ha) |
| $T_3$ | Clomazone 50 EC | 250 (g/ha) |
| $T_4$ | Clomazone 50 EC | 300 (g/ha) |
| $T_5$ | Pretilachlor 50EC | 0.75 (kg/ha) |
| $T_6$ | Manual weeding by hand twice @ 20 and 40 DAT | |
| $T_7$ | Unweeded control | |

**Sowing and Transplanting:**

A specific quantity of seed 30 kg seeds per hectare was involved for all treatments in the field experiment. A rate of 1.0 g $kg^{-1}$ of carbendazim was used to treat the seeds, and then they were kept for 24 hours. The seeds were again treated with 0.8 kg of Azospirillum, shade dried, followed by 12 hours soaking in distilled water, and then incubated in darkness for one full day. They were sown in the nursery bed (3 kg 40 $m^{-2}$), which was applied with diammonium phosphate at 2 kg 40 $m^{-2}$. The well-prepared nursery was maintained following the standard recommendations given by Crop Production Guide (1999). The excessive salts in the solum were leached out until the optimal levels for rice growth were obtained. Consequently, the land was irrigated and puddled with a tractor-drawn cage wheel. After leveling the field with a leveler, the layout of the experimental field was executed. Transplanting was taken up using 20- and 25-days old rice seedlings at 10 cm space within the row and 15 cm among rows.

**Fertilizers and Herbicides Application:**

A fertilizer schedule of nitrogen, phosphorus, and potassium was followed in the current field experiment. The dosage of 120 kg/ha was used as urea for nitrogen (N), 38 kg/ha as single super phosphate for phosphorus ($P_2O_5$), and 38 kg/ha as potash source for potassium ($K_2O$). At the stage of transplanting, 50 % of both nitrogen and potassium with a full dose of phosphorus were applied. The rest doses of nitrogen and potassium (50 %) were used in two splits at the active tillering and panicle time. As per the treatment schedule, the clomazone and pretilachlor were accurately mixed separately in the sand at the rate of 50 kg/ha. These herbicides were broadcasted with water within the third day after transplanting.

**Harvesting and Threshing:**

Samples of rice plants and tested weeds were taken from the field at 20, 40, and 60 days after transplanting (DAT) and prepared for analysis. At the end of the transplanting period, the experimental plots of treated rice were harvested and threshed for getting yields of rice grain and straw separately. The yields of grain and straw were separately registered. Rice yields of straw were air-dried carefully to 15% moisture under sunny conditions, and then their weights were measured.

**Biometric Observations:**

The random selection of tested rice plants was done by choosing five rice plants from each treated plot. The selected plants were tagged and utilized for registering the growth components and yield attributes (biometric observations) at the growth and developmental phases of the studied rice crop. The height of treated plants was estimated at the end of each crop transplanting period (20, 40, and 60 DAT). Three treated plants were uprooted at 10 days intervals. For calculation of crop dry matter production, these plants were air-dried in the shade and then oven-dried at 65°C to remove entirely moisture from plant samples. Finally, their weights were accurately measured and the obtained values were expressed as kg/ha.

Ear bearing tillers counted from an area of 1.0 $m^2$ in each treated plot and the productive tillers were expressed in numbers/$m^2$. Five rice panicles of treated plants were randomly chosen from each treated unit and the length of each panicle was expressed in centimeter (cm). The filled grains number per panicle was counted based on the measured panicles for each plot. 1000 grains were weighed for each treated unit and their obtained values were expressed in grams (g). The produced yields of rice grain and straw from each treated unit were documented. The grain yield of the tested crop was adjusted to 14% moisture content and expressed in kg/ha as per the standard procedures of Yoshida *et al.* (1976). While straw yields of transplanted rice were sun-dried for 5 days and their weights were expressed as kg/ha.

**Observations on Weeds:**

For weed density, a quadrat (0.5 x 0.5m) was used to count weeds at different stages for each treated plot and the obtained values were expressed as No/$m^2$. The random selection of weeds within each quadrat was done and the tested weeds were uprooted at different stages. The weeds were collected from the rice field, then partially dried at the air temperature of the normal room, and fully dried in the oven conditions at 65°C. Accordingly, weed dry matter production (DMP) was calculated and expressed in kg/ha. Based on the weed population, the percentages of weed control efficiency (WCE) were computed according to (Mani *et al*., 1973; Das, 2008) as follows.

$$\textbf{The efficiency of weed control (\%)} = \frac{WPC - WPT}{WPC} \times 100$$

*Where,* WPC is referred to the population of untreated weeds in the control unit, and WPT is referred to the population of weeds in the treated unit.

Weed index is defined as the percent reduction in the seed yield under a particular treatment due to the presence of weeds in comparison to the seed yield obtained in the weed-free plot as suggested by Gill and Kumar (1969) and Shyam *et al.* (2017). It is expressed in percentage and was determined with the help of the following formula:

$$\mathbf{WI} = \frac{X - Y}{X}$$

*Where,* WI = Weed index X = yield from the weed-free plot (hand weeding) Y = yield from the treated plot for which weed index is to be worked out.

**Rice Plant and Weed Analyses:**

The collected samples of treated rice plants and tested weeds were thoroughly prepared and analyzed for macronutrients contents (N, P, and K). The prepared samples of crop plants and weeds were digested and nitrogen concentration was measured using the microkjeldhal method (Humphries (1956). The uptake of nitrogen was computed by multiplying the N content with dry matter production. Phosphorus content was determined by using vanado-molybdo phosphoric yellow color method with the aid of the spectrophotometer (Jackson, 1973). The standard procedures given by Jackson (1973) were used to determine potassium content with the flame photometer. The obtained data were expressed as kg/ha for N, P, and K.

**Data Processing and Statistical Analysis:**

All obtained data of soil, plant, weed properties were subjected to statistical analysis as given by Gomez and Gomez (1984). The 'F' test was done using SPSS software for all treatment units and the differences were compared. The critical differences between treated units were worked out at a 5% probability level and presented in Tables and Figures.

## RESULTS AND DISCUSSION

The experimental results based on soil investigation, laboratory analyses, and the derived parameters pertinent to weed population, macronutrients uptake by crop plants and removal by weeds and yield attributes are presented below.

**Soil Studies of Experiment Field**:

Experimental soil properties across the selected field in the lowland farm at Wadi Al-Mollak were analyzed and presented in Table 2. Gravel, particle size distribution, soil available water (A.W.), and bulk density (ρb) are furnished. Gravel content was few (<50 g/kg) in the studied farm. Soil texture slightly ranged between clay and clay loam. Clay was the most abundant textural class followed by clay loam in studied soils. The clay fraction in the soils ranges from 347 to 582 g/kg. Soil available water values (33.27-50.14%) increased with increasing clay and organic matter. Soil bulk density of ρb values was irregularly varied from 1.10g/cm$^3$ in the surface horizons to 1.31g/cm$^3$ in the subsoil layers. The results of chemical analyses conducted according to Soil Science Division Staff, (2017), $EC_e$ values of soils were 0.72 and 1.51 dS/m indicating the non-saline conditions. Soils of the experiment field range between slightly alkaline (pH: 7.8) and moderately alkaline (pH: 8.2). According to FAO (2006), the results showed a moderately calcareous character in the soils of the selected farm with mean values of $CaCO_3$ ranging from 3.47 to 9.17%. Gypsum concentration was low (0.6-1.2%) across farm-studied soils. Organic carbon (OC) concentration varies from 0.31 to 0.61%. It increased strongly downslope at lowland and with pedon depth, which is attributed to the cultivation activities at the lowland position. Values of CEC increased downslope in the lowland (39.15 - 59.1 cmol (+) kg$^{-1}$) at which the field experiment was conducted. CEC indicated high fertility potential in soils of the field experiment at lowland compared with that of upland. The status of available nitrogen and organic carbon of the soils were medium while the concentrations of available phosphorus and available potassium were high. In general, the initial weighted mean values of CEC and OC, as well as the available macronutrients, indicated the moderate to high soil fertility status.

**Table 2.** Initial weighted mean of soil pedons characteristics for the field of experiment.

| Parameters \ Soil pedon | | P1 | P2 | P3 | P4 | P5 |
|---|---|---|---|---|---|---|
| **1) Physical characteristics** | | | | | | |
| Gravel (g kg$^{-1}$) | | 13 | 5 | 38 | 19 | 45 |
| Clay | Fine-earth fractions (g kg$^{-1}$) | 544 | 582 | 347 | 463 | 371 |
| Silt | | 301 | 275 | 398 | 335 | 204 |
| Fine sand | | 97 | 79 | 80 | 109 | 195 |
| Medium sand | | 25 | 39 | 130 | 75 | 105 |
| Coarse sand | | 33 | 25 | 45 | 18 | 125 |
| Textural class | | Clay | Clay | Clay loam | Clay | Clay loam |
| ρb (Bulk density, g/cm$^3$) | | 1.29 | 1.22 | 1.31 | 1.18 | 1.10 |
| A.W. (Available water, %) | | 48.15 | 50.14 | 37.15 | 41.08 | 33.27 |
| **1) Chemical properties** | | | | | | |
| pH | | 7.88 | 8.1 | 7.9 | 7.8 | 8.2 |
| EC (dS m$^{-1}$) | | 1.12 | 0.94 | 1.05 | 0.72 | 1.51 |
| $CaCO_3$ (%) | | 5.45 | 9.16 | 7.55 | 9.17 | 3.47 |
| Gypsum (%) | | 1.2 | 0.9 | 0.6 | 0.7 | 1.05 |
| **2) Nutrients and fertility properties** | | | | | | |
| Organic carbon (%) | | 0.31 | 0.45 | 0.57 | 0.35 | 0.61 |
| CEC cmol (+) kg$^{-1}$ | | 51.3 | 59.1 | 50.2 | 49.5 | 39.15 |
| Total nitrogen (%) | | 0.15 | 0.43 | 0.17 | 0.27 | 0.34 |
| Total phosphorus (%) | | 0.09 | 0.08 | 0.10 | 0.11 | 0.07 |
| Total potassium (%) | | 0.20 | 0.23 | 0.21 | 0.19 | 0.17 |
| Nitrogen, N | Available contents (kg/ha) | 55 | 65 | 94 | 68 | 105 |
| Phospurus, P | | 19.1 | 25.15 | 19.45 | 20.08 | 15.2 |
| Potassium, K | | 130 | 145 | 202 | 124 | 201 |

**Studies on Weeds:**

**Weed Population:**

Different species of weeds of grasses, sedges, and broad-leaved are the major weed flora in the experimental field of rice at Wadi Al-Mollak. The weed species are *Echinochloa crus-galli* and *Echinochloa colonum* in grasses, *Cyperus difformis* and *Scirpus maritimus* in sedges, and *Eclipta alba* and *Ammania baccifera* in broad-leaved weeds. The results in Table (3) indicated that grass of *Echinochloa crus-galli* was the predominant weed in the early stages at 20 days after transplanting (DAT). The population of weed species across the crop stages in the field experiment was monitored at different periods (20, 40, and 60 DAT). The lowest number of *Echinochloa crus-galli* was recorded in pretilachlor at 20 DAT (0.519), followed by 250 g/ha of clomazone (0.633). Within the periods of 40 and 60 DAT, the lowest number of *Echinochloa crus-galli* was recorded in clomazone @ 300 g/ha. At the period of 60 DAT, the physical method of hand weeding twice registered 0.0, followed by clomazone @ 300 g/ha. In general, 0.75 kg/ha of pretilachlor successfully managed the grasses at 20 DAT compared with

250g/ha of clomazone. While the clomazone @ 300 g/ha recorded the lowest number of grasses compared with the dose of 250g/ha clomazone at 40 DAT. The clomazone @ 300 g/ha at 60 DAT, resulted in the minimum number of grasses compared with hand weeding twice. The lowermost number of *Cyperus difformis* at 20 and 40 DAT was verified in clomazone @ 300 g/ha, whereas the hand weeding twice has found the lowest number of weed population at 60 DAT. The presence of *Scirpus maritimus* was observed at 60 DAT. Irrespective of the stages, the highest number of sedges was found in the unweeded control unit (Table 3).

Regarding broad-leaved weeds, the lowest number of *Eclipta alba* was found at 20 and 40 DAT when this weed was treated with 250 g/ha of clomazone and found at 60 DAT in case of the hand weeding twice followed by 250 g/ha of clomazone and clomazone @ 300 g/ha. In addition, *Ammania baccifera* was observed at the periods of 40 and 60 DAT, and hand weeding twice was an effective method to control this weed. Likewise, broad-leaved weeds were registered the lowest population at 250 g/ha of clomazone at 20 DAT, followed by clomazone @ 300 g/ha. The treated broad-leaved weeds with clomazone at 250 g $ha^{-1}$ were the lowest population within the period of 40 DAT, whereas the lowest number within 60 DAT was achieved by hand weeding twice, followed by clomazone @ 300 g/ha and clomazone at 250 g/ha (Table 3).

**Table 3.** The impacts of herbicides on weed population in the transplanted rice at different periods.

| Treatments | Weed population (No/m²) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Twenty days after transplanting (DAT) | | | | Forty DAT | | | | | Sixty DAT | | | | | | |
| | Grasses | Sedges | Broad-leaved weeds | Total | Grasses | Sedges | Broad-leaved weeds | | Total | Grasses | | Sedges | | Broad-leaved weeds | | Total |
| | *E cg* | *C d* | *E a* | | *E cg* | *C d* | *E a* | *A b* | | *E cg* | *E cc* | *C d* | *S m* | *E a* | *A b* | |
| $T_1$ | 0.929 (6.5) | 0.964 (7.2) | 1.009 (8.2) | 1.378 (21.9) | 0.863 (5.3) | 1.267 (16.5) | 0.833 (4.8) | 0.653 (2.5) | 1.493 (29.1) | 1.316 (18.7) | 0.839 (4.9) | 1.130 (11.5) | 0.301 (1.1) | 1.233 (15.1) | 0.833 (4.8) | 1.764 (56.1) |
| $T_2$ | 0.785 (4.1) | 0.881 (5.6) | 0.699 (3.0) | 1.167 (12.7) | 0.819 (4.6) | 0.996 (7.9) | 0.785 (4.1) | 0.544 (1.5) | 1.303 (18.1) | 1.243 (15.5) | 0.505 (1.2) | 1.004 (8.1) | 0.301 (0.0) | 1.204 (14.0) | 0.792 (4.2) | 1.653 (43.0) |
| $T_3$ | 0.633 (2.3) | 0.691 (2.9) | 0.491 (1.1) | 0.919 (6.3) | 0.691 (2.9) | 0.724 (3.3) | 0.516 (1.9) | 0.643 (2.4) | 1.097 (10.5) | 1.021 (8.5) | 0.653 (2.5) | 0.954 (7.0) | 0.301 (0.0) | 0.839 (6.9) | 0.653 (2.5) | 1.468 (27.4) |
| $T_4$ | 0.740 (3.5) | 0.301 (0.0) | 0.724 (3.3) | 0.944 (6.8) | 0.544 (1.5) | 0.544 (1.5) | 0.716 (3.2) | 0.505 (1.2) | 0.973 (7.4) | 0.914 (6.2) | 0.699 (3.0) | 0.826 (4.7) | 0.301 (0.0) | 0.881 (7.6) | 0.690 (2.9) | 1.422 (24.4) |
| $T_5$ | 0.519 (1.3) | 0.623 (2.2) | 0.544 (1.5) | 0.845 (5.0) | 0.699 (3.0) | 0.653 (2.5) | 0.653 (2.5) | 0.505 (1.2) | 0.964 (7.2) | 0.929 (6.5) | 0.792 (4.2) | 0.903 (6.0) | 0.301 (0.0) | 1.033 (8.8) | 0.635 (4.8) | 1.509 (30.3) |
| $T_6$ | 1.117 (11.1) | 1.021 (8.5) | 1.130 (11.5) | 1.519 (31.1) | 0.954 (7.0) | 0.255 (1.8) | 0.756 (3.7) | 0.301 (0.0) | 1.161 (12.5) | 1.033 (8.8) | 0.613 (2.1) | 0.716 (3.2) | 0.301 (0.0) | 0.763 (3.8) | 0.653 (2.5) | 1.350 (20.4) |
| $T_7$ | 1.27 (11.4) | 1.076 (9.9) | 1.064 (9.6) | 1.517 (30.9) | 1.267 (16.5) | 1.27 (11.4) | 1.033 (8.8) | 0806 (4.4) | 1.634 (41.1) | 1.455 (26.5) | 0.807 (4.4) | 1.265 (16.4) | 0.78 (4.1) | 1.407 (23.5) | 0.708 (3.1) | 1.903 (78.0) |
| **SEd** | 0.023 | 0.022 | 0.103 | 0.024 | 0.035 | 0.024 | 0.019 | 0.016 | 0.039 | 0.030 | 0.018 | 0.025 | 0.013 | 0.026 | 0.016 | 0.033 |
| **P value (0.05)** | 0.047 | 0.045 | 0.222 | 0.047 | 0.050 | 0.045 | 0.035 | 0.031 | 0.081 | 0.061 | 0.036 | 0.050 | 0.026 | 0.056 | 0.033 | 0.069 |

***Explanations:*** All data were subjected to log (x+2) transformation; Figures in parenthesis are original mean values; The mean was calculated for values of the replicates of each treatment; **$T_1$** (Clomazone @150 (g/ha) ; **$T_2$** (Clomazone @200 (g/ha) ; **$T_3$** (Clomazone @ 250 (g/ha); **$T_4$** (Clomazone @300 g/ha); **$T_5$** (Pretilachlor @ 0.75 ( kg/ha); **$T_6$** (Manual weeding by hand twice @ 20 and 40 DAT); **$T_7$** (Unweeded control). ***Ec g*** (*Echinochloa crus- galli*); ***C d*** (*Cyperus difformis*); ***E a*** (*Eclipta alba*); ***E cc*** (*Echinochloa colonum*); ***S m*** (*Scirpus maritimus*); ***A b*** (*Ammania baccifera*).

The total weed population is visualized in Fig. 2. The treatment of clomazone @ 300 g/ha recorded the lowest number of total weeds within both periods of 20 and 40 DAT, followed by 0.75 kg/ha of pretilachlor and 250 g/ha of clomazone. The total weeds were declined at 60 DAT, followed by the collective treatment of clomazone @ 300 g/ha of clomazone only (Fig. 2). The highest total weed population was achieved in the untreated weeds in the seventh treatment (unweeded control) within all tested periods. At 40 and 60 DAT, the weed population increased due to a proportionate increase in weed number and growth of weeds within 20 DAT. The total weed population was dramatically increased within all tested periods from 20 to 60 DAT and then declined thereafter. This might be because of the death of some weeds after completing their life cycle or the shading effect of the crop and taller weeds on short-height weeds with rice plant competition for growth resources. The results indicated that among the herbicidal treatments, clomazone @ 300 g/ha effectively controlled weeds in the crop. The standard herbicide pretilachlor and hand weeding twice were effectively controlled the weeds. Unweeded control resulted in the highest level of weed population followed by clomazone at 150 g/ha because of unchecked weed growth within all periods of the field experiment. These findings confirmed the results given by Hakim *et al.* (2013). Revathi *et al.* (2017) also reported that *Cyperus* is one of the dominant weed species found in transplanted rice, as well as the dominance of grasses in the transplanted rice ecosystems. Whereas, broad-leaved weeds were predominant in the later stages of the studied crop.

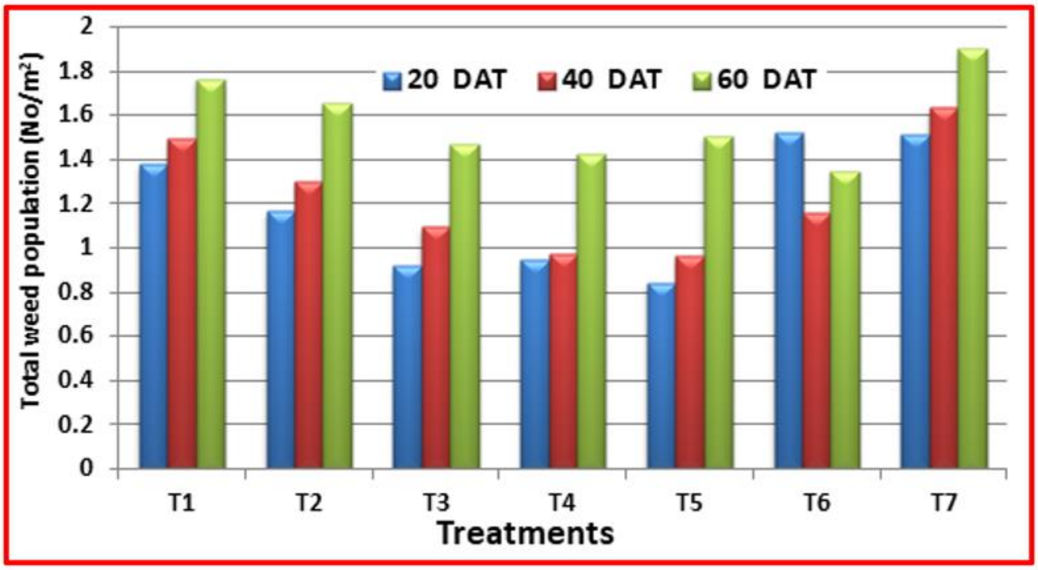


**Fig. 2.** Total weed population response to control treatment under different treated plots.

**Weed Indices and Weed Dry Matter Production:**

The results of weed control efficiency (WCE), weed index (WI), and weed dry matter production (DMP) are presented in Table (4) within three tested times (20, 40, and 60 DAT). The control efficiency of treated weeds with $T_4$ (clomazone @ 300 g/ha) was 84.1 and 78.1% within the periods of twenty and forty days, respectively, and gradually decreased by $T_5$ (pretilachlor) and $T_3$ (clomazone at 250 g/ha). By contrast, the hand weeding twice of $T_6$ registered the highest WCE of 89.49 % at 20 DAT as compared with untreated control. Weed index (WI) showed the loss in yield caused by different treatments of weeds. The values of WI ranged from null in the $T_4$ (clomazone @ 300 g/ha) to 0.453 in the $T_7$ (unweeded unit) (Table 4). The DMP values significantly differed among the treated units of the field experiment. The low values of DMP at 20 DAT were 72.3, 79.4, and 82.1 kg/ha in the $T_4$ (clomazone @ 300 g/ha), in $T_5$ @ pretilachlor, and in $T_3$ @ 250 g/ha of clomazone, respectively. Whereas lowest DMP (125 kg/ha) within 40 DAT was recorded in $T_3$ @ 250 g/ha of clomazone compared to 129 in pretilachlor treatment and 133 in the fourth treatment ($T_4$). The lowest DMP was 231 kg/ha in the treated weed with clomazone @ 300g/ha within 60 DAT compared with 272 kg/ha in the treatment of clomazone @ 250 g/ha, 276 kg/ha in $T_6$ of hand weeding twice and 279 kg/ha in $T_5$ of pretilachlor treatment (Table 4; Fig. 3). The treatments of $T_4$ (clomazone @ 300 g/ha), T3 (250 g clomazone), $T_5$ (pretilachlor), and $T_6$ (hand weeding twice) recorded higher weed control efficiency. These treatments have managed the weeds effectively because of their lower population of weeds and higher efficiency in weed control. By contrast, clomazone at 150 g/ha failed to manage weeds properly across crop stages due to its lower WCE. In the treatment of hand weeding twice, the weed index was the lowest indicating the weed-free state and consequential higher yield in the crop.

**Table 4.** The percentages of weed control efficiency, weed index, and weed dry matter production (kg/ha) at different times of treated rice plots.

| Treatments | The efficiency of weed control (%) | | | Weed index (%) | Dry matter production (kg/ha) | | |
|---|---|---|---|---|---|---|---|
| | 20 days | 40 days | 60 days | | 20 days | 40 days | 60 days |
| $T_1$ | 32.1 | 25.2 | 33.2 | 0.125 | 109 | 180 | 399 |
| $T_2$ | 61.1 | 60.3 | 45.1 | 0.072 | 105 | 155 | 350 |
| $T_3$ | 80.1 | 74.9 | 67.3 | 0.015 | 82.1 | 125 | 272 |
| $T_4$ | 84.1 | 78.1 | 74.9 | 0.000 | 72.3 | 133 | 231 |
| $T_5$ | 81.5 | 76.2 | 63.3 | 0.015 | 79.4 | 129 | 279 |
| $T_6$ | 89.4 | 65.9 | 79.2 | 0.007 | 165 | 153 | 276 |
| $T_7$ | - | - | - | 0.453 | 196 | 310 | 445 |
| SEd | - | - | - | - | 8.04 | 12.1 | 23.1 |
| P value (0.05) | - | - | - | - | 16.1 | 24.9 | 49.1 |

***Explanation:*** **$T_1$** (Clomazone @150 g/ha) ; **$T_2$** (Clomazone @200 g/ha) ; **$T_3$** (Clomazone @ 250 g/ha); **$T_4$** (Clomazone @ 300 g/ha); **$T_5$** (Pretilachlor 50EC @ 0.75 kg/ha); **$T_6$** (Physical weeding by hand twice @ 20 and 40 DAT); **$T_7$** (Unweeded control).

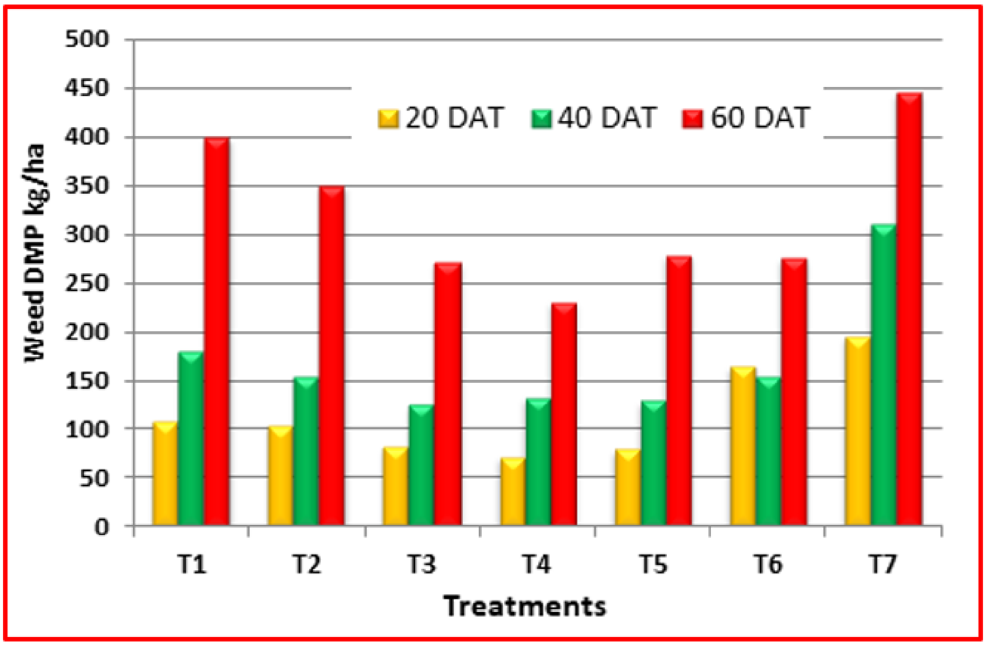


**Fig.3.** Weed dry matter production under different treated plots.

In the unweeded control unit, the weed index was the highest and therefore the yield reduction may be the highest. The grain yield and growth were decreased due to weed competition for nutrients, water, space, and light. The present results of weed indices agree with those obtained by Ramachandra *et al.* (2014). The entire treated units effectively decreased the weed dry weight compared with untreated plots. The weed DMP was inversely proportional to the crop DMP and directly proportional to the weed nutrient removal (Gnanavel and Anbhazhagan, 2010). Clomazone @ 300 g/ha and 250 g/ha registered the lowest values in the weed dry weight. The dry matter production of weeds was decreased due to the effective management of weed species by treated units throughout the developmental and growth stages of the crop. Untreated weeds in the unweeded control unit registered high values in dry matter production of weeds within the growth stages of the crop. This is attributed to an increase in the growth of weeds and their competition to the main cultivated crop (Kumar, 2018).

## Criteria of Rice Growth

The criteria of height rice plants (cm) and rice dry matter production are furnished in Table (5). The effect of treated plots with clomazone on growth components of rice was significant within all periods. The height of rice plants ranged from 44.9 to 53.5, 51.9 to 58.5, and 78.1 to 90.1 cm at 20, 40, and 60 days, respectively. Taller plants were produced under clomazone @ 300 g/ha and it was comparable with all herbicidal treatments except the lower doses of clomazone. By contrast, the height of the plant was the lowest at all the stages under untreated weeds in the control check (Table 5; Fig.4).

**Table 5.** Growth components of rice treated with tested herbicides in relation to physical weeding and control treatments at different times.

| Treated plots | Height of rice plant (cm) at various periods | | | Dry matter production of rice plant at DAT | | |
|---|---|---|---|---|---|---|
| | 20 DAT | 40 DAT | 60 DAT | 20 DAT | 40 DAT | 60 DAT |
| $T_1$ | 46.9 | 53.1 | 80.9 | 2012 | 3157 | 5434 |
| $T_2$ | 49.1 | 53.9 | 83.5 | 2846 | 3435 | 6146 |
| $T_3$ | 51.9 | 59.1 | 89.1 | 3535 | 4274 | 6848 |
| $T_4$ | 53.7 | 58.5 | 90.1 | 3609 | 4349 | 6969 |
| $T_5$ | 49.6 | 55.1 | 84.1 | 3555 | 4287 | 6859 |
| $T_6$ | 46.6 | 56.5 | 86.3 | 1991 | 4088 | 6842 |
| $T_7$-control | 44.9 | 51.9 | 78.1 | 1933 | 2780 | 4945 |
| **SEd** | 1.61 | 1.81 | 2.67 | 33.6 | 34.4 | 56.1 |
| **P value (0.05)** | 3.43 | 3.81 | 5.77 | 72.0 | 74.7 | 120 |

***Explanation:*** **$T_1$** (Clomazone @150 g/ha) ; **$T_2$** (Clomazone @200 g/ha) ; **$T_3$** (Clomazone @ 250 g/ha); **$T_4$** (Clomazone @ 300 g/ha); **$T_5$** (Pretilachlor 50EC @ 0.75 kg/ha); **$T_6$** (Manual weeding by hand twice @ 20 and 40 DAT); **$T_7$** (Unweeded control).

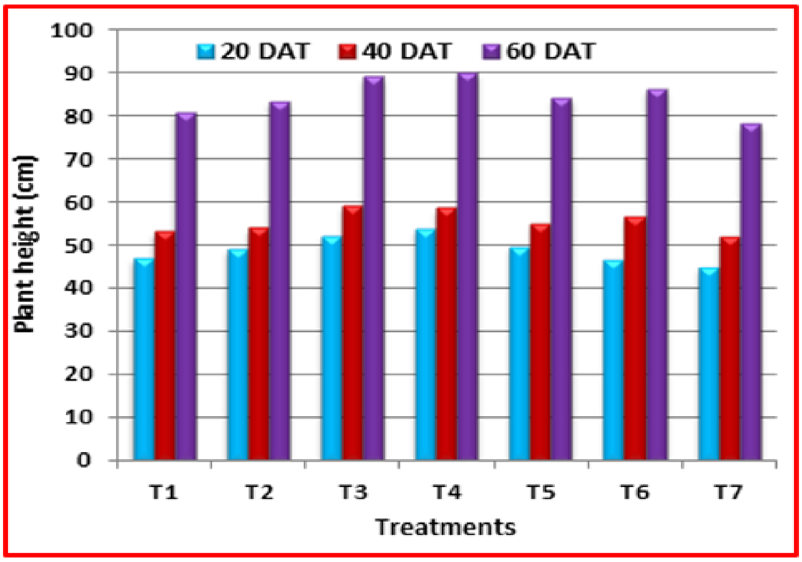


**Fig. 4.** The height of rice plants under different weed control treatments compared to unweeded control ($T_7$) at different periods.

Plant height is an important growth parameter influencing crop yield. The weed management practices adopted in the current research work improved the height of rice plants owing to the lower population of weeds and their biomass. Cutti *et al.*, (2021) similarly detected higher heights of rice plants under the lowest weed competition units. The dose of clomazone @ 300 g/ha and the single dose of clomazone at 250 g/ha resulted in the highest heights of plants during all the growth stages of the crop. This is due to the effective control of emerging weeds at a very early growth phase for effective utilization of all available resources without any weed competition. The plant height was reduced considerably and this might be due to some effect on the physiology of the crop as evident from the phytotoxicity of these doses on rice.

The lowest values of crop height were verified in the untreated herbal weeds during the growth stages or rice ecosystem. The values of dry matter production of treated rice plants by weed control treatments were significantly altered across the growth stages of the studied crop (Table 5). The values of rice dry matter production ranged from 1933 to 3609, 2780 to 4349, and 4945 to 6969 kg/ha at 20, 40, and 60 days respectively. The highest values were registered in the case of the clomazone @ 300 g/ha all studied periods 20, 40, and 60 DAT compared to clomazone at 250 g/ha and pretilachlor. Whereas, the lowest DMP of the rice plants was achieved in the unweeded control (Fig. 5). Weed management practices followed in the current study were registered a positive effect on the rice DMP. The treated plots with the dose of clomazone @ 300 g/ha resulted in the highest DMP of rice compared with 250 g/ha of clomazone. The weeds were completely removed at 20 and 40 DAT in the case of the 6th treatment (hand weeding twice), and therefore the highest rice DMP was achieved. Less weed competition led to optimal growth and improved nutrient uptake by rice under effective weed control treatments resulting in increased dry matter production of the crop (Nivetha *et al.* 2017). The lower dose at 150 g/ha of clomazone resulted in lower dry matter production of rice.

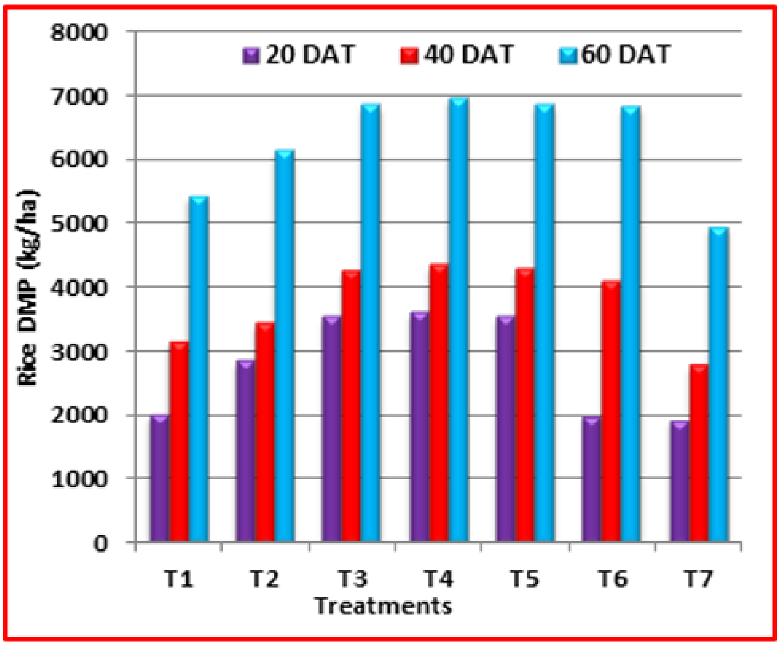


**Fig. 5.** The rice dry matter production at different weed control treatments in relation to unweeded plot ($T_7$) in the rice ecosystem.

**Macronutrients Removal by Weeds in Rice Ecosystem:**

The nitrogen removal by weeds at different stages is presented in Table (6) and visualized in Fig. (6). Within the period of the first 20 days (20 DAT), the nitrogen was removed by weeds in lower (2.44 kg/ha) values when they were treated with the dose of $T_4$ (clomazone @ 300 g/ha) compared with 2.61kg/ha of both $T_3$ (250 g/ha of clomazone) and $T_5$ (0.75 kg/ha of pretilachlor). By contrast, the unweeded treatment recorded the highest nitrogen removal (7.33 kg/ha) by weeds in the rice ecosystem. At 40 DAT, the treatments of clomazone at 250 g/ha, pretilachlor, and clomazone @ 300 g/ha registered 3.41, 3.46, and 3.49 kg/ha of N removal by weeds, respectively. At 60 DAT, clomazone @ 300 g/ha recorded the lowest N removal of 3.88 kg/h, followed by 4.81 kg/ha in hand weeding twice plot. In contrast, the unweeded control at whole crop stages resulted in the highest values of nitrogen removal by weeds that rival rice.

**Table 6.** The tested macronutrients depletion by weeds in the transplanted rice ecosystem.

| Treated plots | Nitrogen depletion (kg/ha) | | | Phosphures removal (kg/ha) | | | Potassium depletion (kg/ha) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 20 days | 40 days | 60 days | 20 days | 40 days | 60 days | 20 days | 40 days | 60 days |
| $T_1$ | 3.91 | 5.25 | 9.08 | 0.393 | 0.519 | 0.525 | 3.42 | 6.34 | 9.49 |
| $T_2$ | 3.59 | 4.36 | 7.11 | 0.388 | 0.462 | 0.555 | 3.19 | 5.32 | 8.24 |
| $T_3$ | 2.61 | 3.41 | 5.25 | 0.265 | 0.309 | 0.424 | 2.27 | 3.86 | 5.59 |
| $T_4$ | 2.44 | 3.49 | 3.88 | 0.222 | 0.335 | 0.261 | 2.22 | 4.17 | 5.04 |
| $T_5$ | 2.61 | 3.46 | 5.17 | 0.258 | 0.392 | 0.363 | 2.25 | 4.17 | 6.56 |
| $T_6$ | 6.92 | 3.85 | 4.81 | 0.686 | 0.416 | 0.335 | 6.37 | 4.74 | 5.79 |
| $T_7$ - control | 7.33 | 9.99 | 11.9 | 0.787 | 1.11 | 1.17 | 6.44 | 11.11 | 12.5 |
| **SEd** | 0.123 | 0.167 | 0.219 | 0.015 | 0.019 | 0.021 | 0.109 | 0.192 | 0.244 |
| **P value (0.05)** | 0.262 | 0.357 | 0.466 | 0.028 | 0.039 | 0.044 | 0.233 | 0.408 | 0.526 |

***Explanation:*** **$T_1$** (Clomazone @150 g/ha) ; **$T_2$** (Clomazone @200 g/ha) ; **$T_3$** (Clomazone @ 250 g/ha); **$T_4$** (Clomazone @ 300 g/ha); **$T_5$** (Pretilachlor 50EC @ 0.75 kg/ha); **$T_6$** (Manual weeding by hand twice @ 20 and 40 DAT); **$T_7$** (Untreated control).

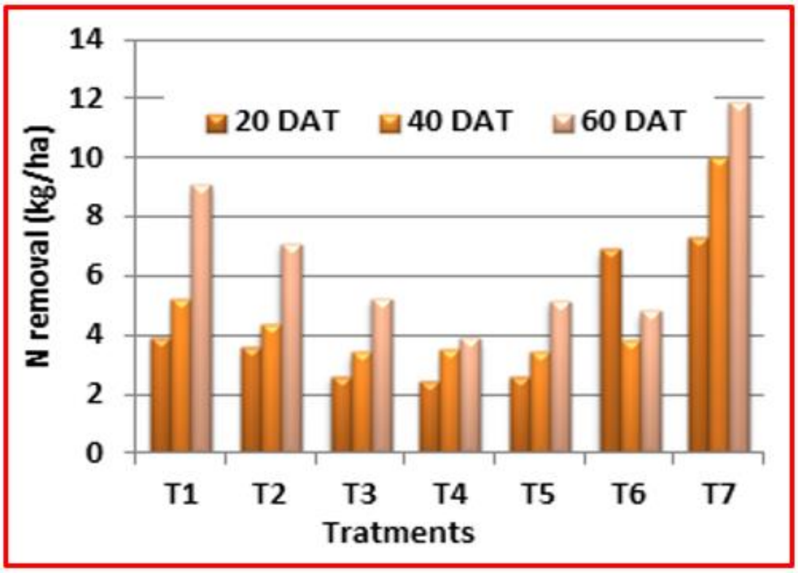


**Fig.6.** Nitrogen depletion by weeds under different management treatments.

As for phosphorus (P), the lowest value of P depletion by weeds was 0.222 kg/ha recorded in the $T_4$ of clomazone @ 300 g/ha followed by 0.258 kg/ha in the $T_5$ pretilachlor and 0.265 kg/ha in the $T_3$ of clomazone at 250 g/ha within twenty days after transplanting. Among the treatments, $T_3$ (250 g/ha of clomazone) verified 0.309 kg/ha of P removal by weeds at 40 DAT, compared to other treatments. Meanwhile, the minimum values of P removal were 0.261 kg/ha achieved from $T_4$ treatment (clomazone @ 300 g/ha) and 0.335 kg/ha in T6 (hand weeding twice). In contrast, the highest P removal at all the stages was in the T7 (Unweeded control) (Table 6; Fig. 7).

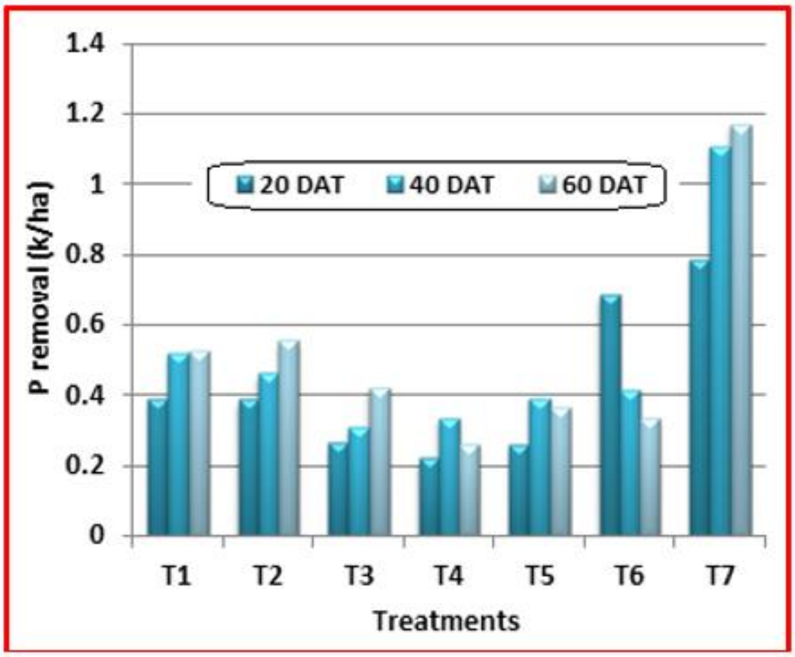


**Fig.7.** Phosphorous removal by weeds under different management treatments

Regarding potassium removal by weeds in the rice ecosystem, there was a significant reduction among the treated plots with clomazone. Clomazone @ 300 g/ha treatment recorded the lowest K removal by 2.22 kg/ha compared with $T_5$ (pretilachlor) and $T_3$ (clomazone at 250 g/ha) at 20 DAT. Furthermore, the lowest K removal at 40 DAT was in $T_3$ (clomazone @ 250 g/ha) compared with $T_4$ (clomazone @ 300 g/ha) and $T_5$ (pretilachlor). Whereas, at 60 DAT, the values of lowest K removal were 5.04 in the $T_4$ (clomazone @ 300 g/ha) and 5.59 kg/ha in $T_3$ (clomazone @ 250 g/ha). The highest K removal was registered in the untreated plot throughout the developmental times of the tested rice plants (Table 6; Fig. 8).

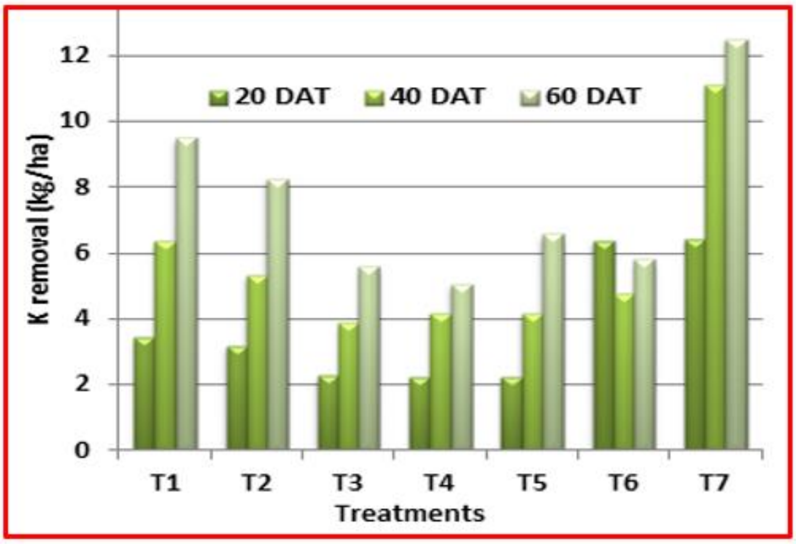


**Fig. 8.** Potassium depletion by weeds in rice ecosystem under different management treatments.

Appling $T_3$ (clomazone at 250 g/ha) and $T_4$ (clomazone 300g/ha) caused lower values of N, P, and K. This is because of lower values in both weed dry matter production and weed population in the case of treated plots with clomazone @ 250 g/ha ($T_3$), clomazone @ 300 g/ha ($T_4$), and hand weeding twice ($T_6$). Standard herbicide pretilachlor also reduced nutrient depletion by weeds. The results of nutrient depletion by weeds in the rice ecosystem are agreed with those got by Issaka *et al.* (2019), and Manisankar *et al.* (2021).

**Macronutrients Uptake by Rice Crop:**

The treated plots in the rice ecosystem showed a significant difference in rice uptake of nitrogen, phosphorus, and potassium at various periods across the entire growth stages of the investigated crop (Table 7; Figs 9, 10, and 11). Among the treated plots, the effective dose was clomazone @ 300 g/ha which recorded a significantly higher value of N uptake of 62.3 kg/ha at 20 DAT and 69.5 kg/ha at 40 DAT. At 60 DAT, the highest value was 89.9 kg/ha of N uptake in $T_4$ of clomazone @ 300 g/ha compared with 89.2 kg/ha in $T_6$ of hand weeding twice. Bu contrast, the unweeded control plot recorded the lowest N uptake irrespective of stages (Table 7; Fig. 9).

**Table 7.** The uptake of tested macronutrients by rice plants concerning the treated units.

| Treatments | N uptake/DAT | | | P uptake/DAT | | | K uptake/DAT | | |
|---|---|---|---|---|---|---|---|---|---|
| | 20 | 40 | 60 | 20 | 40 | 60 | 20 | 40 | 60 |
| $T_1$ | 30.5 | 41.7 | 70.1 | 6.59 | 7.88 | 2.39 | 36.1 | 60.1 | 72.9 |
| $T_2$ | 45.9 | 48.9 | 73.2 | 9.66 | 9.85 | 12.7 | 46.5 | 58.9 | 72.2 |
| $T_3$ | 58.9 | 63.6 | 82.5 | 15.1 | 13.9 | 15.9 | 64.7 | 77.5 | 87.5 |
| T4 | 62.3 | 69.5 | 89.9 | 15.3 | 12.6 | 16.4 | 70.1 | 79.5 | 87.2 |
| T5 | 58.5 | 63.5 | 85.8 | 13.9 | 11.1 | 15.7 | 67.5 | 71.9 | 82.9 |
| T6 | 27.0 | 61.9 | 89.5 | 6.7 | 11.7 | 15.9 | 34.6 | 72.1 | 84.1 |
| T7 | 25.7 | 35.1 | 49.5 | 5.68 | 6.13 | 6.54 | 30.5 | 44.2 | 56.5 |
| **SEd** | 0.615 | 0.588 | 0.752 | 0.148 | 0.108 | 0.144 | 0.658 | 0.666 | 0.709 |
| **P-value (0.05)** | 1.33 | 1.24 | 1.62 | 0.316 | 0.231 | 0.316 | 1.40 | 1.45 | 1.53 |

***Explanation:*** **$T_1$** (Clomazone @150 g/ha) ; **$T_2$** (Clomazone @200 g/ha) ; **$T_3$** (Clomazone @ 250 g/ha); **$T_4$** (Clomazone @ 300 g/ha); **$T_5$** (Pretilachlor 50EC @ 0.75 kg/ha); **$T_6$** (Physical weeding by hand twice @ 20 and 40 DAT); **$T_7$** (Unweeded control).

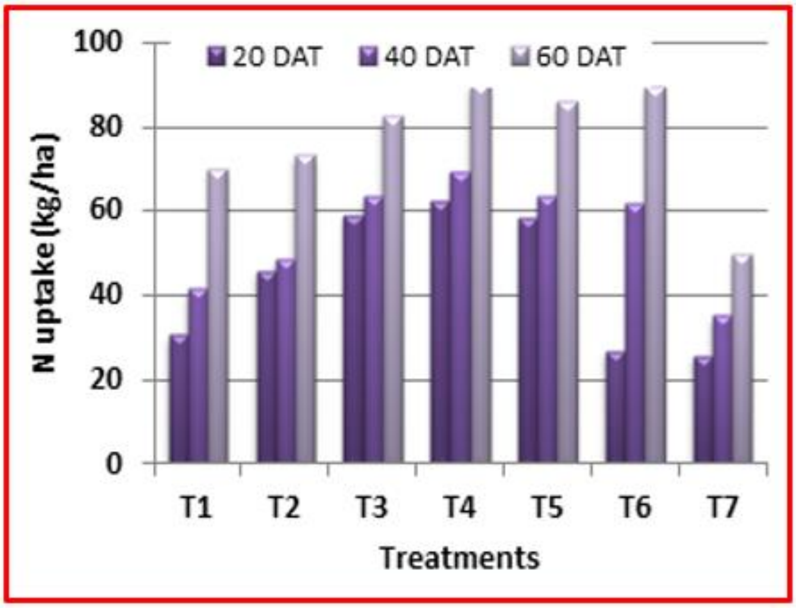


**Fig.9.** Nitrogen uptake by rice under different management treatments

Phosphorus uptake by tested crop indicated a significant variation at different times. The highest values of P uptake were 15.3 kg/ha and 16.1 kg/ha in the treated plots with $T_4$ (clomazone @ 300 g/ha) at 20 and 60 DAT, respectively, as well as 13.9 kg/ha recorded in $T_3$ (clomazone at 250 g/ha) at 40 DAT. In contrast, the untreated plot of $T_7$ showed the lowest value of P uptake during all studied periods (Table 7; Fig. 10).

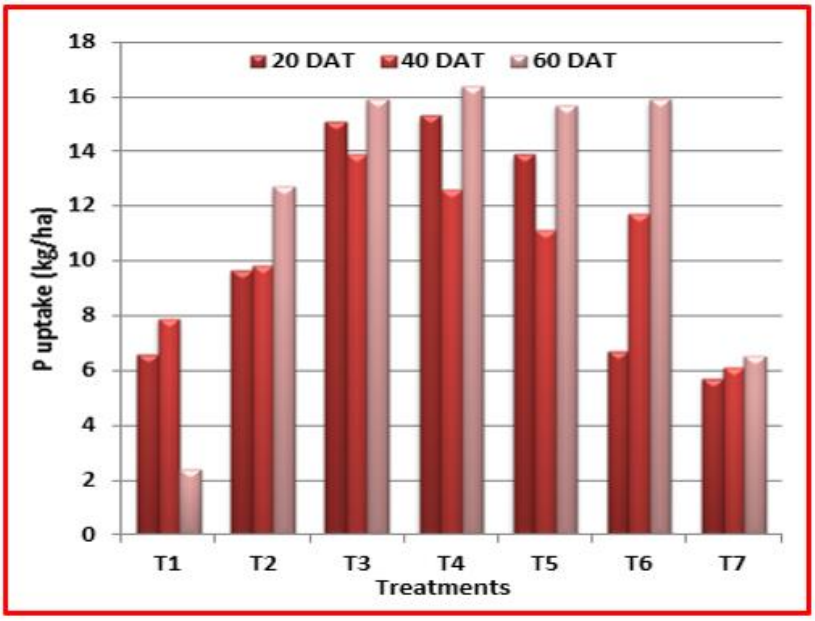


**Fig.10.** Phosphorous uptake by rice under different management treatments

As for potassium uptake by rice, clomazone @ 300 g/ha in $T_4$ caused the higher values of K uptake as 70.1 kg/ha and 79.5 kg/ha at twenty and forty days, respectively, followed by T3 (clomazone @ 250 g/ha). Whereas K uptake was the highest value (87.5 kg/ha) treated with 250 g/ha of clomazone at 60 DAT. By contrast, the lowest values K uptake were 30.5, 44.2, and 56.5 kg/ha detected at 20, 40, and 60 DAT, respectively (Table 7; Fig. 11).

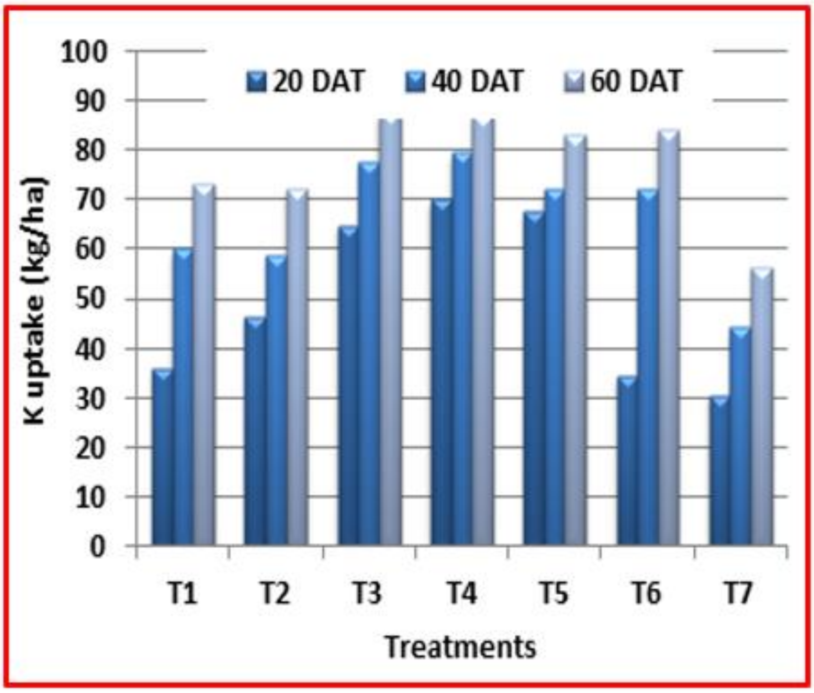


**Fig.11.** Potassium uptake by rice under different treated plots.

The uptake of nutrients by rice indicated that increased proportional to the height of plants and their dry matter production. Furthermore, weed management practices favored an increase in the element uptake by the tested plant. This is because of the operative management of rice herbs and weeds by treated practices, which reduced the nutrient depletion by all studied species of weeds. The dose of $T_4$ (clomazone @ 300 g/ha) and $T_3$

(clomazone at 250 g /ha) recorded successfully values for nutrient uptake by rice crop. The minimum weed competition in the treated plots of the investigated field experiment enhanced nutrient uptake and facilitated higher rice dry matter production. The decreases in the uptake of nutrients at higher and lower doses of clomazone were owing to lower values of crop dry matter and nutrient content by a phytotoxic effect of higher doses and ineffective control of weeds at lower doses. The untreated control plot verified the lowest nutrients uptake in the studied crop at all growth stages (Prakash *et al.* 2013).

**Post-harvest Soil Macronutrients:**

The available concentrations of studied macronutrients were estimated in the soils after harvest and furnished in Table (8). The findings indicated that the untreated plot of rice ($T_7$) of control had higher concentrations of tested macronutrients in soil, followed by 150 g/ha of clomazone. In $T_6$ (hand weeding twice), the lowest contents of studied soil macronutrients were 197 kg/ha for available nitrogen, 20.1 kg/ha for available phosphorus, and 403 kg/ha for available potassium, respectively.

**Table 8.** The available concentrations of macronutrients status in soils after the harvest.

| **Treated plots** | **Available contents (kg/ha)** | | |
|---|---|---|---|
| | **N** | **P** | **K** |
| $T_1$ | 247 | 20.8 | 504 |
| $T_2$ | 244 | 21.3 | 508 |
| $T_3$ | 226 | 20.6 | 506 |
| $T_4$- RM | 226 | 20.5 | 477 |
| $T_5$- Pretilachlor | 236 | 21.4 | 412 |
| $T_{6\text{-handweeding}}$ | 197 | 20.1 | 403 |
| $T_{7\text{ -Unweeded}}$ | 266 | 20.5 | 544 |
| SEd | 2.12 | 0.175 | 4.14 |
| **P-value (0.05)** | 4.51 | 0.367 | 8.91 |

***Explanation:*** **$T_1$** (Clomazone @150 g/ha) ; **$T_2$** (Clomazone @200 g/ha) ; **$T_3$** (Clomazone @ 250 g/ha); **$T_4$** (Clomazone @ 300 g/ha); **$T_5$** (Pretilachlor 50EC @ 0.75 kg/ha); **$T_6$** (physical weed control by hand twice @ 20 and 40 DAT); and **$T_7$** (Unweeded control).

**Rice Growth Traits and Yield:**

The panicle production, length of panicle (cm), filled grains panicle, thousand-grain weight (g), rice grain yield, and rice straw are accurately presented in Table (9). The panicles number varied from 266 in $T_7$ to 407 No/m$^2$ in $T_4$. The results on panicle production as influenced by the treated plots with clomazone that the highest panicles number were found in the plots treated with clomazone @ 300 g/ha followed by 399 in plots treated ($T_3$) with 250 g/ha of clomazone, 394 No/m$^2$ in $T_5$ of pretilachlor, and 353 No/m$^2$ in $T_6$ of hand weeding twice. Untreated plots ($T_7$) found the fewest number of panicles because of the presence of species of weeds that competed with the tested rice plants for space, nutrients, and irrigation water. The highest values of panicle length were 24.3 cm in $T_4$ (clomazone @ 300 g/ha), 23.7 cm in $T_3$ (clomazone 250 g/ha), 23.5 cm in $T_5$ (pretilachlor), and 23.4 cm in hand weeding twice. Unweeded control recorded the lowest panicle length of 18.5 cm (Table 9).

The value numbers of filled grains per panicle significantly varied from 75 in $T_7$ (unweeded plot) to 170 in $T_4$ (clomazone @ 300 g/ha). The influence results of different treated plots on thousand grains weight revealed that numerically higher grain weight (22.1 g) was registered in clomazone @ 300 g/ha, which was closely followed by 20.9 g in $T_6$ (hand weeding twice) and 20.1 g in $T_3$ (clomazone 250 g/ha) (Table 9). Regarding the grain yield, the treated weeds in controlled plots had high values of grain yield in a significant variation among the treatments. The dose of clomazone 300g/ha recorded 5690 kg/ha as the highest grain yield compared with 5665 kg/ha that obtained from the physical control method by hand weeding twice followed by 5613 kg $ha^{-1}$ in the chemical method of clomazone 250 g/ha. The effective dose of clomazone @ 300 g/ha gave an additional yield of 44.08% over control. Furthermore, an increase of 42.1 % grain yield over control was achieved by $T_3$ (250 g/ha of clomazone). The lowest value of grain yield (3949 kg/ha) was detected in the untreated plot of $T_7$ (Table 9; Fig. 12). Concerning straw yield, among the treatments, the effective dose was clomazone @ 300 g/ha. This treatment ($T_4$) achieved the highest value of 8490 kg/ha of straw yield compared to other treated plots. The $T_3$ clomazone 250 g/ha was the second effective dose which registered straw yield of 8445 kg/ha followed by 8380 kg/ha in $T_6$ of hand weeding twice and 8232 kg/ha in pretilachlor compared with the lowest straw yield of 5849 kg $ha^{-1}$ which registered in the untreated plot of $T_7$ (Table 9).

**Table 9.** Growth and yield parameters of rice**.**

| Treatments | Panicle (No $m^{-2}$) | Panicle length (cm) | Filled grains/ panicle | Thousand-grain wt. (g) | Grain yield (kg/ha) | Straw yield (kg/ha) |
|---|---|---|---|---|---|---|
| **$T_1$** | 341 | 19.1 | 82 | 18.5 | 5002 | 7601 |
| **$T_2$** | 349 | 21.5 | 117 | 19.1 | 5288 | 7946 |
| **$T_3$** | 399 | 23.7 | 169 | 20.1 | 5613 | 8445 |
| **$T_4$** | 407 | 24.3 | 170 | 22.1 | 5690 | 8490 |
| **$T_5$** | 394 | 23.5 | 161 | 19.5 | 5611 | 8232 |
| **$T_6$** | 353 | 23.4 | 166 | 20.9 | 5665 | 8380 |
| **$T_7$** | 266 | 18.5 | 75 | 17.2 | 3949 | 5849 |
| **SEd** | 12.9 | 0.791 | 4.92 | 0.167 | 133 | 276 |
| **P-value (0.05)** | 27.6 | 1.70 | 10.6 | 0.359 | 287 | 591 |

***Explanation:*** **$T_1$** (Clomazone @150 g/ha) ; **$T_2$** (Clomazone @200 g/ha) ; **$T_3$** (Clomazone @ 250 g/ha); **$T_4$** (Clomazone @ 300 g/ha); **$T_5$** (Pretilachlor 50EC @ 0.75 kg/ha); **$T_6$** (Physical weeding by hand twice @ 20 and 40 DAT); **$T_7$** (Unweeded control).

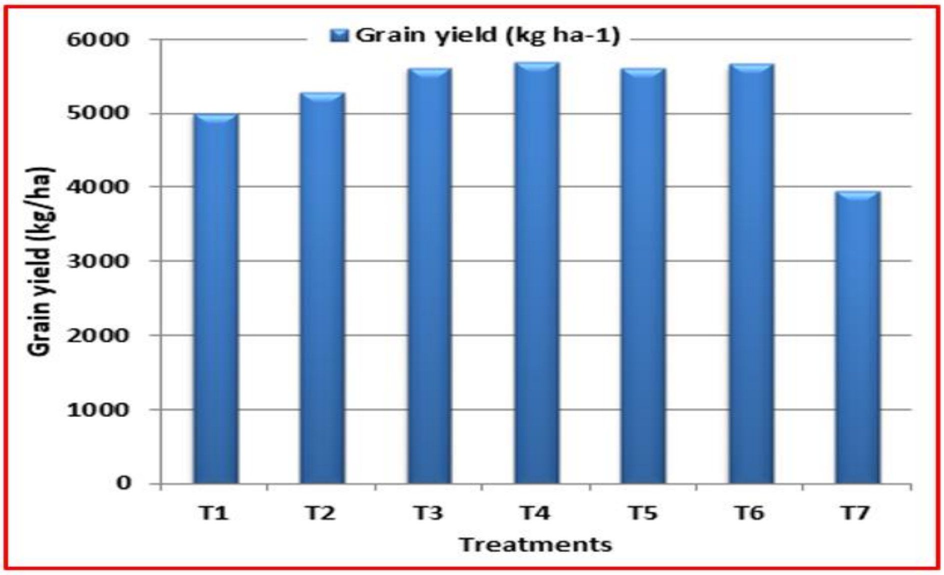


**Fig.12.** Grain yield of rice at treated plots with clomazone.

The highest values of rice panicles number, length of panicle, and filled grains/panicle were found in clomazone @ 300 g/ha ($T_4$), followed by $T_3$ (250 g/ha of clomazone) and the physical control method $T_6$ (hand weeding twice times). The highest values for weight of thousand grains were recorded in $T_4$ and $T_6$ followed by $T_3$. Low competition for growth resources, by weeds, led to higher yield attributing characters of rice. However, the lower values in yield parameters were owing to the severe competition by different weed species for nutrient food, water, air, and light throughout the developmental growth of the rice crop. These findings are supported by Kumar (2018). The effective dose of clomazone @ 300 g/ha registered the highest values of yields for grain and straw due to the effective weed control, less crop toxicity, enhanced growth attributes, uptake of nutrients, and yield attributes. The $T_3$ (clomazone at 250 g/ha) was found to be the optimum dose for getting higher yields. Severe weed competition for growth resources in unweeded control affected yield attributes leading to poor yield. The research findings of the current work are supported by Veeraputhiran and Balasubramanian (2010) and Prashanth *et al.* (2015); Manisankar *et al.* (2021); López-Piňeiro *et al.* (2022).

## CONCLUSION

A field study was conducted at Wadi Al-Mollak, East Delta, Egypt in 2019. with different herbicides doses of clomazone and 0.75 kg/ha of pretilachlor to control rice weeds. Whereas, Six species of weeds were identified throughout the growth stages of the rice crop. They are grasses (*Echinochloa crus-galli* and *Echinochloa colonum)*, sledges (*Cyperus difformis* and *Scirpus maritimus)*, and *Eclipta alba*, and *Ammania baccifera* of broad-leaved weeds. Grasses were the predominant weeds in the early stages, whereas in the latter stages broad-leaved weeds were predominant. The high light findings of this research, it is inferred that the clomazone @ 300 g/ha ($T_4$) and clomazone 250 g/ha ($T_3$) are the most efficient treatment in weeds and increased the height of rice plants, dry matter production of rice plants, uptake of macronutrients by crop, and attributes of crop yield as a result of the required level of weed control in rice ecosystem. Similar effects but in low efficacy were evident with the physical control method of hand weeding twice and pretilachlor. The lower dose of clomazone at 150 g/ha reduced the growth characters but was less effective on weeds. Unweeded control recorded the lowest plant height, DMP of rice, nutrient uptake, and yield due to unchecked weed growth. Among different levels of clomazone, clomazone at 300 and 250 g/ha are the optimum levels for effective management of grasses, sedges, and broad-leaved weeds in the transplanted rice ecosystem. This study demonstrated that the lower rates of clomazone treatment failed to manage weed competition, and consequently, the clomazone @ 250 g/ha and physical method of hand-weeding are the safer methods for controlling the tested grasses, sedges, and broad-leaved and gaining higher grains and straw yields of rice crop. Also, this data is very useful in the sequence of herbicides control of weeds in transplanting rice ecosystem.

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## ARABIC SUMMARY

**تأثير مُبيد الكلومازون على الحشائش، وإمتصاص المٌغذيات الكبرى، وإنتاجية محصول الأرز المشتول في الأراضي المُنخفضة بمصر**

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أُجريت هذه التجربة تحت ظروف الحقل في الأراضي المنخفضة بوادي الملاك، شرق الدلتا، مصر، خلال موسم 2019؛ لدراسة تأثير مبيد الحشائش Clomazone على كلاً من تعداد الحشائش ومكافحتها عبر موسم نمو المحصول، ومعدل إمتصاص العناصر الكبرى من خلال نباتات الأرز Nutrient uptake وإستنفاذها بواسطة الحشائش Nutrient removal، وبالتبعية على نمو Growth وإنتاج محصول الأرز Yield المشتول تحت ظروف الغمر. أوضحت النتائج أن أراضي التجربة الحقلية ذات قوام ناعم (طيني إلى طيني لومي)، متوسطة في المحتوى الميسر للنيتروجين وعالية في المحتوى الميسر لكلا من الفوسفور والبوتاسيوم. وقد تم إجراء هذه التجربة بنظام القطاعات العشوائية بواقع ثلاث مكرارات لكل معاملة من المعاملات لمقارنة فاعلية مبيدات الحشائش Clomazone (150، 200،250 و 300 جم/ هكتار) مع مبيد Preilachlor (0.75 kg/ha)، واقتلاع أو إزالة الحشائش يدوياً مرتين ( بعد 20 و40 يوما من الشتل) بالإضافة الى تجربة المقارنة. وقد تم العثور على الحشائش التالية بمراحل النمو المختلفة لنبات الارز وهي حشيشة *Echinochloa crus-galli* وحشيشة *Echinochloa colonum* وحشيشة *Cyperus difformis* وحشيشة*Scirpus maritimus* وحشيشة *Eclipta alba* وحشيشة *Ammania baccifera*. وقد لوحظ أن الحشائش النجيلية هي السائدة (الدنيبة والسعد) في المراحل المبكرة لنمو الارز، بينما في المراحل المتأخرة كانت الحشائش عريضة الأوراق هي السائدة خصوصاً *Eclipta alba*. حيث ارتفع إجمالي عدد الحشائش الضارة حتى 60 يوم من الشتل ثم انخفض بعد ذلك. كما سجلت المعاملات Clomazone300g/ha و Clomazone 250 g/ha اقل ازلة للعناصر N و P و K بواسطة الحشائش الضارة (2.44، 0.222،و 2.22 كجم/هكتار،على التوالي) وذلك بعد 20 يوم من الشتل. وسجل الكلومازون 300جم/هكتار أعلى ارتفاع لنبات الأرز حيث وصل الى 90.1 سم وكذلك زيادة إنتاج المادة الجافة للمحاصول 69.69 كجم / هكتار بعد 60 يوم من الشتل. سجل Clomazone300 g/ha أعلى امتصاص للعناصر N، P و K لتصبح 62.3، 15.3، و 70.1 كجم / هكتار بعد 20 يوم من الشتل. وأخيراً سجل Clomazone300g/ha أعلى إنتاجية للارز ليعطي 5690 كجم / هكتار بالمقارنة مع المعاملات الاخرى 250Clomazoneجم / هكتار (5613 كجم / هكتار) ، وإزالة الحشائش يدويًا مرتين (5665 كجم / هكتار) ومبيد Preilachlor (5611 كجم / هكتار). مما سبق بالدراسة الحالية يمكن استنتاج أنه من بين الجرعات المختلفة من الكلومازون، التركيزات 300 و 250 جم /هكتار من مبيد الحشائش كلومازون هما الجرعتان المثليتان لمكافحة الحشائش الضارة في الأرز المشتول، كما فشلت التركيزات المنخفضة في تقليل تعداد الحشائش تحت الدراسة وبالتالي إرتفاع التنافسية بينها وبين المحصول الرئيسي في إستهلاك المغذيات الكبرى من التربة والتأثير بالسلب على مراحل نموه وإنتاجيته. وبناءا عليه؛ فقد أوصت هذه الدراسة بأن المُعدلات المُنخفضة من مبيد كلومازون لم تكن كافية للحد من منافسة الحشائش المبكرة لنباتات الأرز، وبالتالي فإن جرعة 250 جم/ هكتار بالتزامن مع إزالة الأعشاب الضارة بصورة ميكانيكية هما الطريقتان الأكثر أمانًا وفعالية لمكافحة الحشائش المٌختبرة وتقليل إستهلاكها للعناصر الكبرى، مع تحسين مراحل نمو نباتات الأرز وزيادة كفاءة امتصاص المغذيات الكبرى من التربة، والحصول على إنتاجية أعلى من كلاً من الحبوب والقش لمحصول الأرز تحت ظروف الشتل في الأراضي المنخفضة ناعمة القوام بمنطقة شرق الدلتا، جمهورية مصر العربية.