4. RESULTS

In order to achieve the objectives outlined earlier, soil incubation experiments, pot culture experiments and laboratory experiments were carried out. Salient findings of the experiment have been presented and discussed critically in the light of published literature.

Physiochemical Characteristics of the Initial soil:

Various physical and chemical properties of the soil before conducting the experiment are shown in table 2a. Soil was found to have almost neutral reaction with pH value of 6.90 and electrical conductivity as 0.53 d S m^{-1}. The cation exchange capacity of this sandy loam soil was 10.3 c mol (+) kg $^{-1}$. The organic carbon content was 0.59% and available P_2O_5 as extracted with olsen's reagent was 120 kg ha^{-1}. The free $CaCO_3$ was estimated as 0.60%. The total content of zinc, copper and nickel were 355, 235 and 35.0 mg kg^{-1}, respectively. DTPA extractable metals, *viz.* Zn, Cu and Ni were 13.1, 8.7 and 0.65 mg kg^{-1}, respectively.

<u>DTPA and diacid extractable Zinc content in soil at 6 and 12 months period.</u>

The extractability of DTPA for soil Zn as influenced by amendments and added metal is shown in table 3a and fig.2a (After 6 months). On an average, the content of DTPA extractable Zn was significantly increased from 18 mg kg^{-1} (control) to 23.3 mg kg^{-1}(treated) due to addition of Zn at the rate of 20 mg kg^{-1}. The content of DTPA extractable Zn were 22.2, 20.9, 21.1, 18.0 and 21.2 respectively in control, FYM, Phosphate, $CaCO_3$ and FYM+ $CaCO_3$ treated pots. These results show that $CaCO_3$ was most effective in reducing the availability of DTPA Extractable Zn in soils. Other amendments, *viz.* FYM, phosphate, and FYM+ $CaCO_3$ could not reduce the DTPA extractable Zn significantly in control as well as metal treated pots.

Data presented in table 4a and fig. 2a (After 6 months) shows that 36.4, 36.7 and 37.5 mg kg^{-1} Zn were extracted by diacid from control, FYM and Phosphate treated pots, respectively, whereas, this extractant could not extract Zn up to measurable limit (Flame AAS) from $CaCO_3$ and FYM+ $CaCO_3$ treated pots.

To compare the extractability of diacid and DTPA, mean values of extractable Zn as influenced by various amendments, are presented in fig. 2a. Diacid extracted highest amount of Zn followed by DTPA from the soils where no amendment was applied (control). Similar trends were observed in case of FYM and Phosphate treated pots. However, extractability of diacid was practically nil in pots where $CaCO_3$ was applied either alone or in combination with FYM.

Data as given in table 3b and fig.2b. After 12 months show the same trend although amount extracted is lesser than amount of Zn extracted in 6 months by DTPA. When extraction by diacid was studied then values given in table 4a and fig. 2b indicate that this extractant could not extract Zn upto measurable limit. Same trend was observed after 12 months and amount Zn extracted in the presence of different amendments were lesser and not upto measurable limit (table 4b and fig. 3b).

DTPA and diacid extractable copper content in soil at 6 and 12 months period.

The influence of amendments and metal application on the extractability of Cu by DTPA is shown in table 5a and fig. 3a (After 6 months). The mean content of DTPA extractable Cu was 12.6 mg kg^{-1} in control pot, the corresponding values were 13.1, 12.6, 11.8 and 12.4 mg kg^{-1} in the pots treated with FYM, Phosphate, $CaCO_3$ and FYM+ $CaCO_3$, respectively. From these values, it may be observed that the $CaCO_3$ is the most effective amendment to reduce the DTPA extractable Cu in metal contaminated soil. The effect of metal addition was significant and the average content of DTPA extractable Cu was increased from 10.5 to 14.5 mg kg^{-1} in control as compared amended soil.

Data of Cu extraction by DTPA in the presence of different amendments after 12 months also follow the trend as the data in 6 months, although amounts of Cu extracted were lesser in 12 months than in 6 months (table 5b and fig.3b).

The diacid extractable Cu in soils under various treatments is given in table 6a. From control, 20.3 mg kg^{-1} of Cu was extracted by diacid and that in FYM and phosphate treated pots were 19.0 and 18.5 mg kg^{-1}, respectively. However, the diacid failed to extract this metal up to analytically measurable limits (FAAS) from the pots treated with either $CaCO_3$ or $CaCO_3$ along with FYM. As in the case of aforesaid extractants, diacid also extracted significantly higher amount of Cu from the pots where metal was applied.

The fig. 3a. indicates that there was a significant reduction in DTPA extractable Cu compared to diacid in $CaCO_3$ and FYM+$CaCO_3$ treated soils over control.

The data in table 6b and fig.3b indicated that the extraction of Cu by diacid after 12 months show that diacid is not extracting the metal Cu upto measureable limit from the pots containing amendment $CaCO_3$ or combination of amendments $CaCO_3$+FYM. But diacid extracted significantly higher amount of Cu from the pots where the metal was applied.

DTPA and diacid extractable nickel content in soil at 6 and 12 months period.

Table 7a and fig.4a (After 6 months) shows the Ni control as extracted by DTPA from soils treated with different amendments. In control, Ni content was 0.86 mg kg^{-1} and the average content of Ni in pots treated with FYM, phosphate, $CaCO_3$ and FYM+ $CaCO_3$ were 1.00, 1.04, 0.67 and 0.78 respectively. Among the treatments $CaCO_3$ was successful in reducing the DTPA extractable Ni in metal contaminated soils followed by FYM + $CaCO_3$. In case of FYM and phosphate treated soils, DTPA extracted more amount of Ni compared to control. Metal application has significantly increased the DTPA extractable Ni from 0.58 (control) to 1.16 mg kg^{-1} in pots where the metal was applied.

Extraction of Ni by DTPA as given by data in table 7b and fig. 4b after 12 months follows the same trend as trend represented in the extraction in 6 month. Although amount extracted in 12 months are lesser than in 6 months. It is also clear that amendment $CaCO_3$ is successful in reducing the DTPA extractable Ni followed by $CaCO_3$+FYM. In case of FYM and SSP, DTPA extracted more amount of Ni over control.

Diacid extractable Ni contents in control and amended soils are given in table 8a and fig.4a. On an average, 2.28, 2.38 and 2.74 mg kg^{-1} of Ni were extracted by diacid from control, FYM and phosphate treated pots respectively. As in case of Zn and Cu, diacid was unsuccessful in extracting any measurable amount of Ni from either $CaCO_3$ or FYM+$CaCO_3$ treated pots. Metal application increased the diacid extractable Ni from 1.33 (control) to 1.67 mg kg^{-1} in metal applied soils.

Extraction of Ni by diacid as given by data in table 8b and fig.4b after 12 months shows that is in case of Zn and Cu, diacid is unsuccessful in extracting any measureable amount of Ni from either $CaCO_3$ or with combination of $CaCO_3$+FYM.

By and large, the ability of DTPA, and diacid to extract metals from control, FYM and phosphate treated soils followed the same order of magnitudes. But the diacid could not extract the metals up to analytically measurable limit (flame AAS) from soils where $CaCO_3$ is added either alone or in combination with FYM. To have a clear picture of relative extractability of these reagents under different treatments, mean values of extractable metals were computed separately for control, FYM and phosphate treated soils, and $CaCO_3$ and FYM+$CaCO_3$ treated soils (Table 9a). The mean values of extractable metals were also computed taking all treatments together.

Results show that extracted amount of Zn is maximum by diacid (36.86 mg kg^{-1}) followed by DTPA (21.4 mg kg^{-1}). When control, FYM and phosphate treated soils were considered. This implies that decreasing order of extractability of these two extractants is diacid followed by DTPA.

Extracted amount of Cu was higher by diacid (19.27 mg kg^{-1}) followed by DTPA (12.8 mg kg^{-1}) when control, FYM and phosphate treated soils were considered like Zn, $CaCO_3$ and $CaCO_3$+FYM treated soils, DTPA extracted (12.1mg kg^{-1}) where amount by diacid was not detectable. Hence ascending order of their extractability of Cu is DTPA and diacid.

Results show that average amount of Ni extracted by diacid (2.47 mg kg^{-1}) followed by DTPA (0.97 mg kg^{-1}) when control , FYM and phosphate treated soils were considered. However in $CaCO_3$ and $CaCO_3$+FYM treated soils DTPA extracted highest amount of Ni (0.73 mg kg^{-1}). Where as diacid failed to extract any detectable quantity of Ni.

Mean values of extractable metals for extractants DTPA and diacid as given in table 9a. and 9b.(after 6 and 12 months) show that trend of extraction in increasing order with amendments FYM and SSP is DTPA < Diacid. In the presence of amendments $CaCO_3$ and combination of ($CaCO_3$+FYM), DTPA extracted measurable amount but amount extracted by diacid is not detectable as indicated in table 9a. and 9b.

Put Culture Experiment

Brassica juncea (2009-10)

Data on drymatter yield of *Brassica juncea* (Indian Mustard) at flowering stage as influenced by various treatments of amendments and added metals have been presented in Table10 and fig.5.

Data in clearly indicate that combination with FYM, $CaCO_3$, SSP and $CaCO_3$+ FYM (T_3, T_4, T_5 and T_6) have significantly higher drymatter yield over control T_1 and alone metals added T_2. The dry matter yield with these treatments have values 22.46 g pot $^{-1}$ with T_3, 21.46 g pot $^{-1}$ with T_4, 23.00 g pot $^{-1}$ with T_5 and 21.40 g pot $^{-1}$ with T_6, against 19.23 g pot $^{-1}$and 19.6 g pot^{-1} obtained with control (T_1) and alone added metals T_2.

Table 10. Effect of various treatments of amendments and added metals on drymatter yield of *B.juncea* (Indian Mustard) at flowering:

Code No.	Treatments	Drymatter yield (g pot^{-1}) *B.juncea*
T_1	Control	19.23
T_2	Zn+Cu+Ni	19.6
T_3	Zn+Cu+Ni + FYM	22.46
T_4	Zn+Cu+Ni + $CaCO_3$	21.46
T_5	Zn+Cu+Ni + SSP	23.0
T_6	Zn+Cu+Ni + $CaCO_3$+ FYM	21.4

S.Em. ($\pm$) 0.383

C.D. (5%) 1.223

Zinc Concentration in *Brassica juncea*

Data on Zn Concentration in *Brassica juncea* plants at flowering stage as influenced by various treatments of amendments and added metals have been demonstrated in Table 11 and fig.6.

Data in clearly indicate that Zn concentration in plants increased significantly with combination of amendments and alone T_2, T_3, T_4, T_5 and T_6 over control T_1 the Zn content with these treatments have values 32.5 µg g^{-1} with T_2, 29.8 µg g^{-1} with T_3, 25.8 µg g^{-1} with T_4, 30.17 µg g^{-1} with T_5 and 30.47 µg g^{-1} with T_6 against 16.2 µg g^{-1} obtained with control (T_1). Treatments T_2,T_3,T_5 and T_6 in higher of Zn Concentration than T_4.

When metals were added to soil (amount increased from 16.2 µg g^{-1} to 32.5 µg g^{-1}). To study the effect of amendments on Zn concentration, data (T_3, T_4, T_5 and T_6) clearly indicate that the metal concentration was reduced by amendments because of immobilization of metal in soil by amendments.

Table 11. Effect of various treatments of amendments and added metals on Zinc Concentration in *B.juncea* (Indian Mustard) at flowering:

Code no.	Zn Concentration in *B.juncea* (µg g^{-1})
T_1	16.2
T_2	32.5
T_3	29.8
T_4	25.8
T_5	30.17
T_6	30.47

S.Em. ($\pm$) 0.454

C.D. (5%) 1.45

Copper Concentration in *Brassica juncea*

Data on Cu Concentration in *Brassica juncea* plants at flowering stage as influenced by various treatments of amendments and added metals have been presented in Table 12 and fig.7.

Data in clearly indicate that Cu concentration in plants increased significantly with combination of amendments and alone T_2, T_3, T_4, T_5 and T_6 over control T_1 the Cu content with these treatments have values 14.16 μg g^{-1} with T_2, 12.76 μg g^{-1} with T_3, 11.6 μg g^{-1} with T_4, 11.66 μg g^{-1} with T_5 and 12.4 μg g^{-1} with T_6 against 10.23 μg g^{-1} obtained with control (T_1). Treatments T_2 higher Cu Concentration than T_3, T_4,T_5 and T_6.

When metals were added to soil (amount increased from 10.23 μg g^{-1} to 14.16 μg g^{-1}). To study the effect of amendments on Cu concentration, data (T_3, T_4, T_5 and T_6) clearly indicate that the metal concentration was reduced by amendments because of immobilization of metal in soil by amendments.

Table 12. Effect of various treatments of amendments and added metals on Copper Concentration in *B.juncea* (Indian Mustard) at flowering:

Code no.	Cu Concentration in *B.juncea* (μg g^{-1})
T_1	10.23
T_2	14.16
T_3	12.76
T_4	11.6
T_5	11.66
T_6	12.4

S.Em. ($\pm$) 0.37

C.D. (5%) 1.181

Nickel Concentration in *Brassica juncea*

Data on Ni Concentration in *Brassica juncea* plants at flowering stage as influenced by various treatments of amendments and added metals have been presented in Table 13 and fig.8.

Data in clearly indicate that Ni concentration in plants increased significantly with combination of amendments and alone T_2, T_3, T_4, T_5 and T_6 over control T_1 the Ni content with these treatments have values 3.96 µg g^{-1} with T_2, 3.23 µg g^{-1} with T_3, 2.53 µg g^{-1} with T_4, 2.5 µg g^{-1} with T_5 and 2.6 µg g^{-1} with T_6 against 2.6 µg g^{-1} obtained with control (T_1) Treatments T_2 and T_3 higher Ni Concentration than T_4,T_5 and T_6.

When metals were added to soil (amount increased from 2.6 µg g^{-1} to 3.96 µg g^{-1}). To study the effect of amendments on Ni concentration, data (T_3, T_4, T_5 and T_6) clearly indicate that the metal concentration was reduced by amendments because of immobilization of metal in soil by amendments.

Table 13. Effect of various treatments of amendments and added metals on Nickel Concentration of *B.juncea* (Indian Mustard) at flowering**:**

Code no.	Ni Concentration in *B.juncea* (µg g^{-1})
T_1	2.6
T_2	3.96
T_3	3.23
T_4	2.53
T_5	2.5
T_6	2.6

S.Em. ($\pm$) 0.148

C.D. (5%) 0.472

Zinc uptake in *Brassica juncea*

Data pertaining to Zn uptake by *Brassica juncea* as influenced by various treatments of amendments and added metals have been demonstrated in Table 14 and fig.9.

A personal of data displayed in indicated that Zn uptake in *B.juncea* at flowering recorded with various treatments T_2, T_3, T_4, T_5 and T_6 were significantly higher than T_1 (Control) the treatments showed a variation in the values of Zn uptake 636.9 µg pot $^{-1}$ with T_2, 669.53 µg pot^{-1} with T_3, 553.3 µg pot^{-1} with T_4, 694.03 µg pot^{-1} with T_5 and 651.83 µg pot^{-1} with T_6 as against 311.46 µg pot^{-1} observed with control (T_1) . Treatments T_2, T_3, T_5 and T_6 marginal higher than T_4

Table 14. Effect of various treatments of amendments and added metals on Zinc uptake in *B.juncea* (Indian Mustard) at flowering:

Code no.	Zn uptake in *B.juncea* (µg pot $^{-1}$)
T_1	311.46
T_2	636.9
T_3	669.53
T_4	553.3
T_5	694.03
T_6	651.83

S.Em. ($\pm$) 54.732

C.D. (5%) 174.692

Copper uptake in *Brassica juncea*

Data pertaining to Cu uptake by *Brassica juncea* as influenced by various treatments of amendments and added metals have been shown in Table 15. and fig.10.

A personal of data displayed in indicated that Cu uptake in *B.juncea* at flowering recorded with various treatments T_2, T_3, T_4, T_5 and T_6 were significantly higher than T_1 (Control). The treatments showed a variation in the values of Cu uptake 277.56 µg pot $^{-1}$ with T_2, 286.5 µg pot^{-1} with T_3, 248.43 µg pot^{-1} with T_4, 268.23 µg pot^{-1} with T_5 and 265.46 µg pot^{-1} with T_6 as against 196.96 µg pot^{-1} observed with control (T_1) . the treatments T_2,T_3,T_5 and T_6 marginal higher than T_4.

When metals were added to soil (amount increased from 196.96 µg pot^{-1} to 277.56 µg pot^{-1}). To study the effect of amendments on Cu uptake, data (T_4, T_5 and T_6) clearly indicate that the metal uptake was reduced by amendments because of immobilization of metal in soil by amendments.

Table 15. Effect of various treatments of amendments and added metals on Copper uptake in *B.juncea* (Indian Mustard) at flowering:

Code no.	Cu uptake in *B.juncea* (µg pot $^{-1}$)
T_1	196.96
T_2	277.56
T_3	286.5
T_4	248.43
T_5	268.23
T_6	265.46

S.Em. ($\pm$) 7.839

C.D. (5%) 25.021

Nickel uptake in *Brassica juncea*

Data pertaining to Ni uptake by *Brassica juncea* as influenced by various treatments of amendments and added metals have been shown in Table 16 and fig.11.

A close examination of data shown in clearly indicated that Ni uptake in *B.juncea* at flowering recorded with various treatments T_2, T_3, T_4, T_5 and T_6 were significantly higher than T_1 (Control). The treatments showed a variation in the values of Ni uptake 77.73 µg pot^{-1} with T_2, 72.53 µg pot^{-1} with T_3, 54.3 µg pot^{-1} with T_4, 57.36 µg pot^{-1} with T_5 and 55.56 µg pot^{-1} with T_6 as against 49.96 µg pot^{-1} observed with control (T_1) . The treatments T_2, T_3, T_5 and T_6 marginal higher than T_4.

When metals were added to soil (amount increased from 49.96 µg pot^{-1} to 77.73 µg pot^{-1}). To study the effect of amendments on Ni uptake, data (T_3, T_4, T_5 and T_6) clearly indicate that the metal uptake was reduced by amendments because of immobilization of metal in soil by amendments.

Table 16. Effect of various treatments of amendments and added metals on Nickel uptake of *B.juncea* (Indian Mustard) at flowering:

Code no.	Ni uptake in *B.juncea* (µg pot^{-1})
T_1	49.96
T_2	77.73
T_3	72.53
T_4	54.3
T_5	57.36
T_6	55.56

S.Em. (±) 2.946

C.D. (5%) 9.404

***Brassica campestris* (2009-10)**

Data on drymatter yield of *Brassica campestris* (Yellow Sarson) at flowering stage as influenced by various treatments of amendments and added metals have been presented in Table 17 and fig.12.

Data in clearly indicate that combination with FYM, $CaCO_3$, SSP, and $CaCO_3$+FYM (T_3, T_4, T_5 and T_6) had significantly higher drymatter yield over control T_1 and alone metals added T_2. The dry matter yield with these treatments have values 18.8 g pot $^{-1}$ with T_3, 16.63 g pot^{-1} with T_4, 19.96 g pot $^{-1}$ with T_5, and 19.7 g pot $^{-1}$ with T_6 against 15.46 g pot $^{-1}$ and 15.6 g pot $^{-1}$ obtained with control (T_1) and alone added metals T_2

Table 17. Effect of various treatments of amendments and added metals on drymatter yield of *Brassica campestris* (Yellow Sarson) at flowering:

Code No.	Treatments	Drymatter yield (g pot^{-1}) *B.campestris*
T_1	Control	15.46
T_2	Zn+Cu+Ni	15.6
T_3	Zn+Cu+Ni + FYM	18.8
T_4	Zn+Cu+Ni + $CaCO_3$	16.63
T_5	Zn+Cu+Ni + SSP	19.96
T_6	Zn+Cu+Ni + $CaCO_3$+FYM	19.7

S.Em. ($\pm$) 0.424
C.D. (5%) 1.354

Zinc Concentration in *Brassica campestris*

Data on Zn Content in *Brassica campestris* plants at flowering stage as influenced by various treatments of amendments and added metals have been demonstrated in Table 18 and fig.13.

Data in clearly indicate that Zn concentration in plants increased significantly with combination of amendments and alone T_2, T_3, T_4, T_5 and T_6 over control $T_{1.}$ The Zn content with these treatments have values 41.23 µg g^{-1} with T_2, 37.16 µg g^{-1} with T_3, 34.23 µg g^{-1} with T_4, 35.9 µg g^{-1} with T_5 and 36.0 µg g^{-1} with T_6 against 20.63 µg g^{-1} obtained with control (T_1) The treatments T_2,T_3,T_5 and T_6 in higher of Zn Concentration than T_4.

When metals were added to soil (amount increased from 20.63 µg g^{-1} to 41.23 µg g^{-1}). To study the effect of amendments on Zn concentration, data (T_3, T_4, T_5 and T_6) clearly indicate that the metal concentration was reduced by amendments because of immobilization of metal in soil by amendments.

Table 18. Effect of various treatments of amendments and added metals on Zinc Concentration in *Brassica campestris* (Yellow Serson) at flowering:

Code no.	Zn Concentration in *B.campestris* (µg g^{-1})
T_1	20.63
T_2	41.23
T_3	37.16
T_4	34.23
T_5	35.9
T_6	36.0

S.Em. ($\pm$) 0.473
C.D. (5%) 1.511

Copper Concentration in *Brassica campestris*

Data on Cu Content in *Brassica campestris* plants at flowering stage as influenced by various treatments of amendments and added metals have been presented in Table 19 and fig.14.

Data in clearly indicate that Cu concentration in plants increased significantly with combination of amendments and alone T_2, T_3, T_4, T_5 and T_6 over control T_1 . The Cu concentration with these treatments have values 12.8 µg g^{-1} with T_2, 10.93 µg g^{-1} with T_3, 10.5 µg g^{-1} with T_4, 8.5 µg g^{-1} with T_5 and 8.8 µg g^{-1} with T_6 against 8.36 µg g^{-1} obtained with control (T_1) The treatments $T_{2,}$ $T_{3,}$ T_4 in higher of Cu Concentration than T_5 and T_6.

When metals were added to soil (amount increased from 8.36 µg g^{-1} to 12.8 µg g^{-1}). To study the effect of amendments on Cu concentration, data (T_3, T_4, T_5 and T_6) clearly indicate that the metal concentration was reduced by amendments because of immobilization of metal in soil by amendments.

Table 19. Effect of various treatments of amendments and added metals on Copper Concentration in *Brassica campestris* (Yellow Serson) at flowering:

Code no.	Cu Concentration in *B.campestris* (µg g^{-1})
T_1	8.36
T_2	12.8
T_3	10.93
T_4	10.5
T_5	8.5
T_6	8.8

S.Em. ($\pm$) 0.468
C.D. (5%) 1.495

Nickel Concentration in *Brassica campestris*

Data on Ni Concentration in *Brassica campestris* plants at flowering stage as influenced by various treatments of amendments and added metals have been presented in Table 20 and fig.15.

Data in clearly indicate that Ni concentration in plants increased significantly with combination of amendments and alone T_2, T_3, T_4, T_5 and T_6 over control T_1. The Ni concentration with these treatments have values 6.5 μg g^{-1} withT_2, 5.6 μg g^{-1} with T_3, 5.2 μg g^{-1} with T_4, 4.66 μg g^{-1} with T_5 and 4.7 μg g^{-1} with T_6 against 3.53 μg g^{-1} obtained with control (T_1) The treatments T_2, T_3, T_4 in higher of Ni Concentration than T_5 and T_6.

When metals were added to soil (amount increased from 3.53 μg g^{-1} to 6.5 μg g^{-1}). To study the effect of amendments on Ni concentration, data (T_3, T_4, T_5 and T_6) clearly indicate that the metal concentration was reduced by amendments because of immobilization of metal in soil by amendments.

Table 20. Effect of various treatments of amendments and added metals on Nickel Concentration in *Brassica campestris* (Yellow Sarson) at flowering:

Code no.	Ni Concentration in *B. campestris* (μg g^{-1})
T_1	3.53
T_2	6.5
T_3	5.6
T_4	5.2
T_5	4.66
T_6	4.7

S.Em. ($\pm$) 0.426
C.D. (5%) 1.36

Zinc uptake in *Brassica campestris*

Data pertaining to Zn uptake by *B. campestris* influenced by various treatments of amendments and added metals have been demonstrated in Table 21 and fig.16.

A personal of data displayed in indicated that Zn uptake in *B. campestris* at flowering recorded with various treatments T_2, T_3, T_4, T_5 and T_6 were significantly higher than T_1 (Control). The treatments showed a variation in the values of Zn uptake 642.8 µg pot $^{-1}$ with T_2, 698.53 µg pot^{-1} with T_3, 569.16 µg pot^{-1} with T_4, 716.93 µg pot^{-1} with T_5 and 709.23 µg pot^{-1} with T_6 as against 319.53 µg pot^{-1} observed with control (T_1). The treatments T_2, T_3, T_5 and T_6 marginal higher than T_4.

Table 21. Effect of various treatments of amendments and added metals on Zinc uptake in *Brassica campestris* (Yellow Sarson) at flowering:

Code no.	Zn uptake in *B. campestris* (µg pot $^{-1}$)
T_1	319.53
T_2	642.8
T_3	698.53
T_4	569.16
T_5	716.93
T_6	709.23

S.Em. (±) 13.526

C.D. (5%) 43.173

Copper uptake in *Brassica campestris*

Data pertaining to Cu uptake by *B.campestris* as influenced by various treatments of amendments and added metals have been shown in Table 22 and fig.17.

A close examination of data displayed in Clearly indicated that Cu uptake in *B. campestris* at flowering recorded with various treatments T_2, T_3, T_4, T_5 and T_6 were significantly higher than T_1 (Control). The treatments showed a variation in the values of Cu uptake 199.73 µg pot $^{-1}$ with T_2, 205.6 µg pot^{-1} with T_3, 174.5 µg pot^{-1} with T_4, 169.3 µg pot^{-1} with T_5 and 173.53 µg pot^{-1} with T_6 as against 128.93 µg pot^{-1} observed with control (T_1) . The treatments T_2,T_3,T_4 and T_6 marginal higher than T_5.

When metals were added to soil (amount increased from 128.93 µg pot^{-1} to 199.73 µg pot^{-1}). To study the effect of amendments on Cu uptake, data (T_4, T_5 and T_6) clearly indicate that the metal concentration was reduced by amendments because of immobilization of metal in soil by amendments.

Table 22. Effect of various treatments of amendments and added metals on Copper uptake in *Brassica campestris* (Yellow Sarson) at flowering:

Code no.	Cu uptake in *B. campestris* (µg pot $^{-1}$)
T_1	128.93
T_2	199.73
T_3	205.6
T_4	174.5
T_5	169.3
T_6	173.53

S.Em. (±)	7.781
C.D. (5%)	24.834

Nickel uptake in *Brassica campestris*

Data pertaining to Ni uptake by *campestris* as influenced by various treatments of amendments and added metals have been shown in Table 23 and fig.18.

A close examination of data shown in clearly indicated that Ni uptake in *B. campestris* at flowering recorded with various treatments T_2, T_3, T_4, T_5 and T_6 were significantly higher than T_1 (Control). The treatments showed a variation in the values of Ni uptake 101.13 μg pot $^{-1}$ with T_2, 105.13 μg pot^{-1} with T_3, 86.6 μg pot^{-1} with T_4, 93.23 μg pot^{-1} with T_5 and 92.46 μg pot^{-1} with T_6 as against 54.5 μg pot^{-1} observed with control (T_1) . The treatments T_2,T_3,T_5 and T_6 marginal higher than T_4.

When amendments were added decrease in Ni uptake in plant was observed because of immobilization of metal in soil by the application of amendments.

Table 23. Effect of various treatments of amendments and added metals on Nickel uptake of *B. campestris* (Yellow Sarson) at flowering:

Code no.	Ni uptake in B. *campestris* (μg pot $^{-1}$)
T_1	54.5
T_2	101.13
T_3	105.13
T_4	86.6
T_5	93.23
T_6	92.46

S.Em. (±) 7.298
C.D. (5%) 23.293

***Brassica carinata* (2009-10)**

Data on drymatter yield of *Brassica carinata* (Ethiopian Mustard) at flowering stage as influenced by various treatments of amendments and added metals have been presented in Table 24 and fig.19.

Data in clearly indicate that combination with FYM, $CaCO_3$, SSP and $CaCO_3$+FYM (T_3, T_4, T_5 and T_6) had significantly marginal increase drymatter yield over control T_1 and alone metals added T_2. The drymatter yield with these treatments have values 32.3 g pot $^{-1}$ with T_3, 30.06 g pot^{-1}with T_4, 31.93 g pot $^{-1}$ with T_5, and 31.36 g pot $^{-1}$ with T_6 against 28.66 g pot $^{-1}$ and 29.13 g pot $^{-1}$ obtained with control (T_1) and alone added metals $T_{2.}$

Table 24. Effect of various treatments of amendments and added metals on drymatter yield of *Brassica carinata* (Ethiopian Mustard) at flowering:

Code No.	Treatments	Drymatter yield (g pot^{-1}) *B. carinata*
T_1	Control	28.66
T_2	Zn+Cu+Ni	29.13
T_3	Zn+Cu+Ni + FYM	32.3
T_4	Zn+Cu+Ni + $CaCO_3$	30.06
T_5	Zn+Cu+Ni + SSP	31.93
T_6	Zn+Cu+Ni + $CaCO_3$+FYM	31.36

S.Em. ($\pm$)	0.781
C.D. (5%)	2.493

Zinc Concentration in *Brassica carinata*

Data on Zn Content in *Brassica carinata* plants at flowering stage as influenced by various treatments of amendments and added metals have been demonstrated in Table 25 and fig.20.

Data in clearly indicate that Zn concentration in plants increased significantly with combination of amendments and alone T_2, T_3, T_4, T_5 and T_6 over control $T_{1.}$ The Zn content with these treatments have values 37.0 µg g^{-1} with T_2, 35.86 µg g^{-1} with T_3, 32.36 µg g^{-1} with T_4, 32.0 µg g^{-1} with T_5 and 32.9 µg g^{-1} with T_6 against 17.63 µg g^{-1} obtained with control (T_1) The treatments T_2, and T_3, in higher of Zn Concentration than $T_{4,}$ $T_{5,}$ T_6.

When metals were added to soil (amount increased from 17.63 µg g^{-1} to 37.0 µg g^{-1}). To study the effect of amendments on Zn concentration, data (T_3, T_4, T_5 and T_6) clearly indicate that the metal concentration was reduced by amendments because of immobilization of metal in soil by amendments.

Table 25. Effect of various treatments of amendments and added metals on Zinc Concentration in *Brassica carinata* (Ethiopian Mustard) at flowering:

Code no.	Zn Concentration in *B. carinata* (µg g^{-1})
T_1	17.63
T_2	37.0
T_3	35.86
T_4	32.36
T_5	32.0
T_6	32.9

S.Em. ($\underline{+}$) 0.65
C.D. (5%) 2.074

Copper Concentration in *Brassica carinata*

Data on Cu Content in *Brassica carinata* plants at flowering stage as influenced by various treatments of amendments and added metals have been presented in Table 26 and fig.21.

Data in clearly indicate that Cu concentration in plants increased significantly with combination of amendments and alone T_2, T_3, T_4, T_5 and T_6 over control T_1 . The Cu concentration with these treatments have values 9.56 µg g^{-1} with T_2, 8.4 µg g^{-1} with T_3, 8.03 µg g^{-1} with T_4, 7.2 µg g^{-1} with T_5 and 7.4 µg g^{-1} with T_6 against 6.5 µg g^{-1} obtained with control (T_1) The treatments $T_{2,}$ in higher of Cu Concentration than $T_{3,}$ $T_{4,}$ T_5 and T_6.

When metals were added to soil (amount increased from 6.5 µg g^{-1} to 9.56 µg g^{-1}). To study the effect of amendments on Cu concentration, data (T_3, T_4, T_5 and T_6) clearly indicate that the metal concentration was reduced by amendments because of immobilization of metal in soil by amendments.

Table 26. Effect of various treatments of amendments and added metals on Copper Concentration in *Brassica carinata* (Ethiopian Mustard) at flowering:

Code no.	Cu Concentration in *B. carinata* (µg g^{-1})
T_1	6.5
T_2	9.56
T_3	8.4
T_4	8.03
T_5	7.2
T_6	7.4

S.Em. ($\pm$) 0.354
C.D. (5%) 1.131

Nickel Concentration in *Brassica carinata*

Data on Ni Concentration in *Brassica carinata* plants at flowering stage as influenced by various treatments of amendments and added metals have been presented in Table 27 and fig.22.

Data in clearly indicate that Ni concentration in plants increased significantly with combination of amendments and alone T_2, T_3, T_4, T_5 and T_6 over control T_1 the Ni concentration with these treatments have values 6.53 µg g^{-1} with T_2, 5.6 µg g^{-1} with T_3, 4.66 µg g^{-1} with T_4, 5.5 µg g^{-1} with T_5 and 4.7 µg g^{-1} with T_6 against 3.56 µg g^{-1} obtained with control (T_1) The treatments T_2 in higher of Ni Concentration than T_3,T_4,T_5 and T_6.

When metals were added to soil (amount increased from 3.56 µg g^{-1} to 6.53 µg g^{-1}). To study the effect of amendments on Ni concentration, data (T_3, T_4, T_5 and T_6) clearly indicate that the metal concentration was reduced by amendments because of immobilization of metal in soil by amendments.

Table 27. Effect of various treatments of amendments and added metals on Nickel Concentration in *Brassica carinata* (Ethiopian Mustard) at flowering:

Code no.	Ni Concentration in *B. carinata* (µg g^{-1})
T_1	3.56
T_2	6.53
T_3	5.6
T_4	4.66
T_5	5.5
T_6	4.7

S.Em. ($\pm$) 0.486
C.D. (5%) 1.551

Zinc uptake in *Brassica carinata*

Data pertaining to Zn uptake by *B. carinata* as influenced by various treatments of amendments and added metals have been shown in Table 28 and fig.23.

A personal of data displayed in indicated that Zn uptake in *B. carinata* at flowering recorded with various treatments T_2, T_3, T_4, T_5 and T_6 were significantly higher than T_1 (Control). The treatments showed a variation in the values of Zn uptake 1076.96 μg pot $^{-1}$ with T_2, 1158.56 μg pot^{-1} with T_3, 974.06 μg pot^{-1} with T_4, 1020.4 μg pot^{-1} with T_5 and 1031.63 μg pot^{-1} with T_6 as against 504.73 μg pot^{-1} observed with control (T_1). The treatments T_2, T_3, T_5 and T_6 marginal higher than T_4.

When metals were added to soil (amount increased from 504.73 μg pot^{-1} to 1076.96 μg pot^{-1}). To study the effect of amendments on Zn uptake, data (T_3, T_4, T_5 and T_6) clearly indicate that the metal uptake was reduced by amendments because of immobilization of metal in soil by amendments.

Table 28. Effect of various treatments of amendments and added metals on Zinc uptake in *Brassica carinata* (Ethiopian Mustard) at flowering:

Code no.	Zn uptake in *B. carinata* (μg pot $^{-1}$)
T_1	504.73
T_2	1076.96
T_3	1158.56
T_4	974.06
T_5	1020.4
T_6	1031.63

S.Em. (±) 25.349
C.D. (5%) 80.91

Copper uptake in *Brassica carinata*

Data pertaining to Cu uptake by *B. carinata* as influenced by various treatments of amendments and added metals have been shown in Table 29 and fig.24.

A personal of data displayed in indicated that Cu uptake in *B. carinata* at flowering recorded with various treatments T_2, T_3, T_4, T_5 and T_6 were significantly higher than T_1 (Control). The treatments showed a variation in the values of Cu uptake 278.33 µg pot $^{-1}$ with T_2, 271.33 µg pot^{-1} with T_3, 241.73 µg pot^{-1} with T_4, 230.4 µg pot^{-1} with T_5 and 231.26 µg pot^{-1} with T_6 as against 186.53 µg pot^{-1} observed with control (T_1) . The treatments T_2,T_3,T_4 and T_6 marginal higher than T_5.

When amendments were added decrease in Cu uptake in plant was observed because of immobilization of metal in soil by the application of amendments.

Table 29. Effect of various treatments of amendments and added metals on Copper uptake in *Brassica carinata* (Ethiopian Mustard) at flowering:

Code no.	Cu uptake in *B. carinata* (µg pot $^{-1}$)
T_1	186.53
T_2	278.33
T_3	271.33
T_4	241.73
T_5	230.4
T_6	231.26

S.Em. (±) 13.072
C.D. (5%) 44.278

Nickel uptake in *Brassica carinata*

Data pertaining to Ni uptake by *B. carinata* as influenced by various treatments of amendments and added metals have been shown in Table 30 and fig.25.

A personal of data displayed in table 30 indicated that Ni uptake in *B. carinata* at flowering recorded with various treatments T_2, T_3, T_4, T_5 and T_6 were significantly higher than T_1 (Control). The treatments showed a variation in the values of Ni uptake 189.76 µg pot $^{-1}$ with T_2, 180.8 µg pot^{-1} with T_3, 140.93 µg pot^{-1} with T_4, 174.23 µg pot^{-1} with T_5 and 147.66 µg pot^{-1} with T_6 as against 102.53 µg pot^{-1} observed with control (T_1) . The treatments T_2,T_3,T_5 and T_6 marginal higher than T_4.

When amendments were added decrease in Ni uptake in plant was observed because of immobilization of metal in soil by the application of amendments.

Table 30. Effect of various treatments of amendments and added metals on Nickel uptake of *B. carinata* (Ethiopian Mustard) at flowering:

Code no.	Ni uptake in B. *carinata* (µg pot $^{-1}$)
T_1	102.53
T_2	189.76
T_3	180.8
T_4	140.93
T_5	174.23
T_6	147.66

S.Em. ($\pm$)	15.185
C.D. (5%)	48.467

Brassica napus (2009-10)

Data on drymatter yield of *Brassica napus* (Gobi Sarson) at flowering stage as influenced by various treatments of amendments and added metals have been presented in Table 31 and fig.26.

Data in table 31 clearly indicate that combination with FYM, $CaCO_3$, SSP and $CaCO_3$+FYM (T_3, T_4, T_5 and T_6) had significantly higher drymatter yield over control T_1 and alone metals added T_2. The dry matter yield with these treatments have values 31.83 g pot $^{-1}$ with T_3, 29.13 g pot^{-1} with T_4, 30.06 g pot $^{-1}$ with T_5, and 31.16 g pot $^{-1}$ with T_6 against 27.66 g pot $^{-1}$ and 28.8 g pot $^{-1}$ obtained with control (T_1) and alone added metals T_2.

Table 31. Effect of various treatments of amendments and added metals on drymatter yield of *Brassica napus* (Gobi Sarson) at flowering:

Code No.	Treatments	Drymatter yield (g pot^{-1}) *B. napus*
T_1	Control	27.66
T_2	Zn+Cu+Ni	28.8
T_3	Zn+Cu+Ni + FYM	31.83
T_4	Zn+Cu+Ni + $CaCO_3$	29.13
T_5	Zn+Cu+Ni + SSP	30.06
T_6	Zn+Cu+Ni + $CaCO_3$+FYM	31.16

S.Em. ($\pm$) 0.424
C.D. (5%) 1.354

Zinc Concentration in *Brassica napus*

Data on Zn Concentration in *Brassica napus* plants at flowering stage as influenced by various treatments of amendments and added metals have been presented in Table32 and fig. 27.

Data Presented in table 32 clearly indicate that Zn concentration in plants increased significantly with combination of amendments and alone T_2, T_3, T_4, T_5 and T_6 over control T_1. The Zn content with these treatments have values 37.26 µg g^{-1} with T_2, 34.56 µg g^{-1} with T_3, 34.66 µg g^{-1} with T_4, 30.5 µg g^{-1} with T_5 and 32.16 µg g^{-1} with T_6 against 18.36 µg g^{-1} obtained with control (T_1) The treatments T_2,$T_3$$T_4$ and T_6, in higher of Zn Concentration than T_5.

When metals were added to soil (amount increased from 18.36 µg g^{-1} to 37.26 µg g^{-1}). To study the effect of amendments on Zn concentration, data (T_3, T_4, T_5 and T_6) clearly indicate that the metal concentration was reduced by amendments because of immobilization of metal in soil by amendments.

Table 32. Effect of various treatments of amendments and added metals on Zinc Concentration in *Brassica napus* (Gobi Sarson) at flowering:

Code no.	Zn Concentration in *B. napus* (µg g^{-1})
T_1	18.36
T_2	37.26
T_3	34.56
T_4	34.66
T_5	30.5
T_6	32.16

S.Em. (±) 0.598

C.D. (5%) 1.91

Copper Concentration in *Brassica napus*

Data on Cu Concentration in *Brassica napus* plants at flowering stage as influenced by various treatments of amendments and added metals have been presented in Table 33 and fig.28.

The Data Presented in clearly indicate that Cu concentration in plants increased significantly with combination of amendments and alone T_2, T_3, T_4, T_5 and T_6 over control T_1. The Cu content with these treatments have values 9.2 µg g^{-1} with T_2, 8.23 µg g^{-1} with T_3, 7.46 µg g^{-1} with T_4, 7.2 µg g^{-1} with T_5 and 6.8µg g^{-1} with T_6 against 6.2 µg g^{-1} obtained with control (T_1) The treatments T_2,T_3,T_4 and T_5 in higher of Cu Concentration than T_6.

Table 33. Effect of various treatments of amendments and added metals on Copper Concentration in *Brassica napus* (Gobi Sarson) at flowering:

Code no.	Cu Concentration in *B. napus* (µg g^{-1})
T_1	6.2
T_2	9.2
T_3	8.23
T_4	7.46
T_5	7.2
T_6	6.8

S.Em. ($\pm$) 0.317
C.D. (5%) 1.012

Nickel Concentration in *Brassica napus*

Data on Ni Concentration in *Brassica napus* plants at flowering stage as influenced by various treatments of amendments and added metals have been presented in Table 34 and fig.29.

The data presented in table 34 clearly indicate that Ni concentration in plants increased significantly with combination of amendments and alone T_2, T_3, T_4, T_5 and T_6 over control T_1 the Ni concentration with these treatments have values 5.2 µg g^{-1} with T_2, 5.6 µg g^{1} with T_3, 4.86 µg g^{-1} with T_4, 5.4 µg g^{-1} with T_5 and 4.86 µg g^{-1} with T_6 against 3.56 µg g^{-1} obtained with control (T_1) The treatments $T_{2,}T_{3,}T_5$ in marginal higher of Ni Concentration than T_4 and T_6.

When amendments were added decrease in Ni concentration in plant was observed because of immobilization of metal in soil by the application of amendments.

Table 34. Effect of various treatments of amendments and added metals on Nickel Concentration in *Brassica napus* (Gobi Sarson) at flowering:

Code no.	Ni Concentration in *B. napus* (µg g^{-1})
T_1	3.56
T_2	5.2
T_3	5.6
T_4	4.86
T_5	5.4
T_6	4.86

S.Em. ($\pm$)	0.321
C.D. (5%)	1.025

Zinc uptake in *Brassica napus*

Data pertaining to Zn uptake by *B. napus* as influenced by various treatments of amendments and added metals have been shown in Table 35 and fig.30.

A close examination of data shown in table 35 clearly indicated that Zn uptake in *B. napus* at flowering recorded with various treatments T_2, T_3, T_4, T_5 and T_6 were significantly higher than T_1 (Control). The treatments showed a variation in the values of Zn uptake 1071.8 µg pot $^{-1}$ with T_2, 1100.3 µg pot^{-1} with T_3, 1010.9 µg pot^{-1} with T_4, 918.23.4 µg pot^{-1} with T_5 and 1003.1 µg pot^{-1} with T_6 as against 507.66 µg pot^{-1} observed with control (T_1). The treatments T_2, T_3, T_4 and T_6 marginal higher than T_5.

When amendments were added decrease in Zn uptake in plant was observed because of immobilization of metal in soil by the application of amendments.

Table 35. Effect of various treatments of amendments and added metals on Zinc uptake in *Brassica napus* (Gobi Sarson) at flowering:

Code no.	Zn uptake in *B. napus* (µg pot $^{-1}$)
T_1	507.66
T_2	1071.8
T_3	1100.3
T_4	1010.9
T_5	918.23
T_6	1003.1

S.Em. (±) 24.106
C.D. (5%) 74.94

Copper uptake in *Brassica napus*

Data pertaining to Cu uptake by *B. napus* as influenced by various treatments of amendments and added metals have been shown in Table 36 and fig.31.

A close examination of data shown in table 36 clearly indicated that Cu uptake in *B. napus* at flowering recorded with various treatments T_2, T_3, T_4, T_5 and T_6 were significantly higher than T_1 (Control). The treatments showed a variation in the values of Cu uptake 265.06 µg pot $^{-1}$ with T_2, 261.83 µg pot^{-1} with T_3, 217.9 µg pot^{-1} with T_4, 216.43 µg pot^{-1} with T_5 and 211.86 µg pot^{-1} with T_6 as against 170.5 µg pot^{-1} observed with control (T_1) . The treatments T_2, T_3, T_4 and T_5 marginal higher than T_6.

Table 36. Effect of various treatments of amendments and added metals on Copper uptake in *Brassica napus* (Gobi Sarson) at flowering:

Code no.	Cu uptake in *B. napus* (µg pot $^{-1}$)
T_1	170.5
T_2	265.06
T_3	261.83
T_4	217.9
T_5	216.43
T_6	211.86
S.Em. (±)	10.418
C.D. (5%)	33.251

Nickel uptake in *Brassica napus*

Data pertaining to Ni uptake by *Brassica napus* as influenced by various treatments of amendments and added metals have been shown in Table 37 and fig.32.

A close examination of data shown in table 37 clearly indicated that Ni uptake in *B. napus* at flowering recorded with various treatments T_2, T_3, T_4, T_5 and T_6 were significantly higher than T_1 (Control). The treatments showed a variation in the values of Ni uptake 149.9 µg pot $^{-1}$ with T_2, 178.43 µg pot^{-1} with T_3, 142.23 µg pot^{-1} with T_4, 161.8 µg pot^{-1} with T_5 and 151.43 µg pot^{-1} with T_6 as against 98.86 µg pot^{-1} observed with control (T_1) . The treatments T_2, T_3, T_5 and T_6 marginal higher than T_4.

Table 37. Effect of various treatments of amendments and added metals on Nickel uptake of *B. napus* (Gobi Sarson) at flowering:

Code no.	Ni uptake in B. *napus* (µg pot $^{-1}$)
T_1	98.86
T_2	149.9
T_3	178.43
T_4	142.23
T_5	161.8
T_6	151.43

S.Em. ($\pm$)	9.935
C.D. (5%)	31.709

Brassica nigra (2009-10)

Data on drymatter yield of *Brassica nigra* (*Banarasi Rai*)at flowering stage as influenced by various treatments of amendments and added metals have been presented in Table 38 and fig.33.

Data in clearly indicate that combination with FYM, $CaCO_3$, SSP and $CaCO_3$+FYM (T_3, T_4, T_5 and T_6) had not significant the drymatter yield over control T_1 and alone metals added T_2. The dry matter yield with these treatments have values 30.16 g pot $^{-1}$ with T_3, 29.06 g pot^{-1} with T_4, 31.9 g pot $^{-1}$ with T_5, and 30.1 g pot $^{-1}$ with T_6.

Table 38. Effect of various treatments of amendments and added metals on drymatter yield of *Brassica nigra (Banarasi Rai*) at flowering:

Code No.	Treatments	Drymatter yield (g pot^{-1}) B. nigra
T_1	Control	28.86
T_2	Zn+Cu+Ni	28.4
T_3	Zn+Cu+Ni + FYM	30.16
T_4	Zn+Cu+Ni + $CaCO_3$	29.06
T_5	Zn+Cu+Ni + SSP	31.9
T_6	Zn+Cu+Ni + $CaCO_3$+FYM	30.1

S.Em. ($\pm$)	0.891
C.D. (5%)	N.S.

Zinc Concentration in *Brassica nigra*

Data on Zn Concentration in *Brassica nigra* plants at flowering stage as influenced by various treatments of amendments and added metals have been presented in Table 39 and fig.34.

Data Presented in table 39 clearly indicate that Zn concentration in plants increased significantly with combination of amendments and alone T_2, T_3, T_4, T_5 and T_6 over control $T_{1.}$ The Zn content with these treatments have values 30.5 µg g^{-1} with T_2, 24.73 µg g^{-1} with T_3, 24.0 µg g^{-1} with T_4, 25.13 µg g^{-1} with T_5 and 24.0 µg g^{-1} with T_6 against 15.6 µg g^{-1} obtained with control (T_1) The treatments T_2, and T_5, in higher of Zn Concentration than $T_{5,}T_4$, and T_6.

When metals were added to soil (amount increased from 15.6 µg g^{-1} to 30.5 µg g^{-1}). To study the effect of amendments on Zn concentration, data (T_3, T_4, T_5 and T_6) clearly indicate that the metal concentration was reduced by amendments because of immobilization of metal in soil by amendments.

Table 39. Effect of various treatments of amendments and added metals on Zinc Concentration in *Brassica nigra* (Banarasi Rai) at flowering:

Code no.	Zn Concentration in *B. nigra* (µg g^{-1})
T_1	15.6
T_2	30.5
T_3	24.73
T_4	24.0
T_5	25.13
T_6	24.0

S.Em. (±)	0.729
C.D. (5%)	2.328

Copper Concentration in *Brassica nigra*

Data on Cu Concentration in *Brassica nigra* plants at flowering stage as influenced by various treatments of amendments and added metals have been presented in Table 40 and fig.35.

The Data Presented in clearly indicate that Cu concentration in plant increased significantly with combination of amendments and alone T_2, T_3, T_4, T_5 and T_6 over control T_1 . The Cu content with these treatments have values 11.4 μg g^{-1} with T_2, 9.66 μg g^{-1} with T_3, 9.33 μg g^{-1} with T_4, 8.33 μg g^{-1} with T_5 and 8.8 μg g^{-1} with T_6 against 6.56 μg g^{-1} obtained with control (T_1) The treatments T_2 in higher of Cu Concentration.

When amendments were added decrease in Cu concentration in plant was observed because of immobilization of metal in soil by the application of amendments.

Table 40. Effect of various treatments of amendments and added metals on Copper Concentration in *Brassica nigra* (Banarasi Rai) at flowering:

Code no.	Cu Concentration in *B. nigra* (μg g^{-1})
T_1	6.56
T_2	11.4
T_3	9.66
T_4	9.33
T_5	8.33
T_6	8.8

S.Em. (±)	0.574
C.D. (5%)	1.833

Nickel Concentration in *Brassica nigra*

Data on Ni Concentration in *Brassica nigra* plants at flowering stage as influenced by various treatments of amendments and added metals have been presented in Table 41 and fig.36.

The data presented in table 41 clearly indicate that Ni concentration in plants increased significantly with combination of amendments and alone T_2, T_3, T_4, T_5 and T_6 over control T_1. The Ni content with these treatments have values 4.8 µg g^{-1} with T_2, 4.73 µg g^{-1} with T_3, 3.53 µg g^{-1} with T_4, 4.33 µg g^{-1} with T_5 and 3.1 µg g^{-1} with T_6 against 2.76 µg g^{-1} obtained with control (T_1) The treatments T_2,and T_3, in higher of Ni.

When metals were added to soil (amount increased from 2.76 µg g^{-1} to 4.8 µg g^{-1}). To study the effect of amendments on Ni concentration, data (T_3, T_4, T_5 and T_6) clearly indicate that the metal concentration was reduced by amendments because of immobilization of metal in soil by amendments.

Table 41. Effect of various treatments of amendments and added metals on Nickel Concentration in *Brassica nigra* (Banarasi Rai) at flowering:

Code no.	Ni Concentration in *B. nigra* (µg g^{-1})
T_1	2.76
T_2	4.8
T_3	4.73
T_4	3.53
T_5	4.33
T_6	3.1

S.Em. ($\pm$) 0.308
C.D. (5%) 0.983

Zinc uptake in *Brassica nigra*

Data pertaining to Zn uptake by *B. nigra* as influenced by various treatments of amendments and added metals have been shown in Table 42 and fig.37.

A personal of data displayed in table 42 clearly indicated that Zn uptake in *B. nigra* at flowering recorded with various treatments T_2, T_3, T_4 T_5 and T_6 were significantly higher than T_1 (Control). The treatments showed a variation in the values of Zn uptake 864.66 µg pot $^{-1}$ with T_2, 744.56 µg pot^{-1} with T_3, 698.26 µg pot^{-1} with T_4, 803.9 µg pot^{-1} with T_5 and 721.53 µg pot^{-1} with T_6 as against 449.26 µg pot^{-1} observed with control (T_1). The treatments T_2,T_3,T_5 and T_6 marginal higher than T_4.

When metals were added to soil (amount increased from 449.26 µg pot^{-1} to 864.66 µg pot^{-1}). To study the effect of amendments on Zn uptake, data (T_3, T_4, T_5 and T_6) clearly indicate that the metal uptake was reduced by amendments because of immobilization of metal in soil by amendments.

Table 42. Effect of various treatments of amendments and added metals on Zinc uptake in *Brassica nigra* (Banarasi Rai) at flowering:

Code no.	Zn uptake in *B. nigra* (µg pot $^{-1}$)
T_1	449.26
T_2	864.66
T_3	744.56
T_4	698.26
T_5	803.9
T_6	721.53

S.Em. (±)	31.592
C.D. (5%)	100.53

Copper uptake in *Brassica nigra*

Data pertaining to Cu uptake by *B. nigra* as influenced by various treatments of amendments and added metals have been shown in Table 43 and fig.38.

A personal of data displayed in table 43 indicated that Cu uptake in *B. nigra* at flowering recorded with various treatments T_1, T_2, T_3, T_4, T_5 and T_6 were not significant. The treatments showed a variation in the values of Cu uptake 189.36 µg pot $^{-1}$ with T_1, 294.63 µg pot $^{-1}$ with T_2, 290.9 µg pot^{-1} with T_3, 272.2 µg pot^{-1} with T_4, 267.6 µg pot^{-1} with T_5 and 264.9 µg pot^{-1} with T_6

When amendments were added decrease in Cu uptake in plant was observed because of immobilization of metal in soil by the application of amendments.

Table 43. Effect of various treatments of amendments and added metals on Copper uptake in *Brassica nigra* (Banarasi Rai) at flowering:

Code no.	Cu uptake in *B. nigra* (µg pot $^{-1}$)
T_1	189.36
T_2	294.63
T_3	290.9
T_4	272.2
T_5	267.6
T_6	264.9

S.Em. (±) 25.49
C.D. (5%) N.S.

Nickel uptake in *Brassica nigra*

Data pertaining to Ni uptake by *nigra* as influenced by various treatments of amendments and added metals have been shown in Table 44 and fig.39.

A personal of data displayed in table 44 indicated that Ni uptake in *B. nigra* at flowering recorded with various treatments T_2, T_3, T_4, T_5 and T_6 were significantly higher than T_1 (Control). The treatments showed a variation in the values of Ni uptake 136.03 µg pot $^{-1}$ with T_2, 143.1 µg pot^{-1} with T_3, 102.30 µg pot^{-1} with T_4, 138.73 µg pot^{-1} with T_5 and 92.66 µg pot^{-1} with T_6 as against 79.63 µg pot^{-1} observed with control (T_1) . The treatments T_2, T_3, T_4 and T_5 marginal higher than T_6.

When amendments were added decrease in Ni uptake in plant was observed because of immobilization of metal in soil by the application of amendments.

Table 44. Effect of various treatments of amendments and added metals on Nickel uptake of *B. nigra* (Banarasi Rai) at flowering:

Code no.	Ni uptake in B. *nigra* (µg pot $^{-1}$)
T_1	79.63
T_2	136.03
T_3	143.1
T_4	102.30
T_5	138.73
T_6	92.66

S.Em. (±)	10.017
C.D. (5%)	31.972