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EVALUATION OF NEW FORMULATION QUIZALOFOP-ETHYL (5% EC) FOR WEED MANAGEMENT IN IRRIGATED GROUNDNUT

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ABSTRACT

Field experiment was conducted at Agricultural Research Station, Bhavanisagar of Tamil Nadu Agricultural University during rabi 2012 to evaluate new formulation quizalofop-ethyl (5% EC) for weed management in irrigated groundnut. The experiment was laid out in randomized block design, replicated thrice. Different weed management treatments viz., new formulation early post-emergence quizalofop-ethyl (5% EC) at 37.5, 50, 75, and 100 g/ha, quizalofop-ethyl (targa super) at 37.5, 50 g/ha, pre-emergence pendimethalin at 1.0 kg/ha + hand weeding on 45 DAS, oxyfluorfen at 0.2 kg/ha + hand weeding on 45 DAS, pendimethalin at 1.0 kg/ha + mechanical weeding on 45 DAS, oxyfluorfen at 0.2 kg/ha + mechanical weeding on 45 DAS, pendimethalin at 1.0 kg/ha + layby application of oxyfluorfen at 0.2 kg/ha at 45 DAS, oxyfluorfen at 0.2 kg/ha + layby application of pendimethalin at 1.0 kg/ha at 45 DAS, hand weeding twice on 25 and 45 DAS and unweeded control. Experimental results revealed that early post-emergence application of quizalofop-ethyl 5% EC at 75 g/ha effectively controlled weeds and recorded higher pod yield.

Key words : *Early post-emergence, Groundnut, Pod yield, Weed control efficiency.*

Groundnut (*Arachis hypogaea* L.), is the king of oilseeds, popularly known as "Unpredictable legume". Groundnut habit of slow growth at initial stages makes it more susceptible to several key factors viz., insects, diseases and weeds etc., Among the key factors responsible for low productivity of groundnut, weeds are considered as one of the most important factors. Weeds compete with the crop for nutrients, moisture, light, space and also interfere in pegging and pod development resulting in poor pod yield. Thus, weed management is the foremost critical production factor in groundnut cultivation for realizing higher yield.

In recent times, with advances in herbicide use, weeds are controlled more effectively. Pre and post-emergence herbicides are the best alternative for weed control at critical periods. Use of pre-emergence herbicide becomes ineffective after 20-30 days of sowing and once pegging started, physical method of weeding cannot be used owing to possible damage to the pegs. In such situation, application of post-emergence herbicide is the only option to keep the crop weed free and also to realize higher yield.. Quizalofop-ethyl is a new post-emergence herbicide used to control grassy weeds in broad leaved crops. Early post-emergence herbicide to control weeds without causing phytotoxicity would be more appropriate for better weed management in groundnut. Thus, an experiment was conducted with an objective to evaluate new formulation quizalofop-ethyl (5% EC) for controlling weeds in irrigated groundnut.

MATERIALS AND METHODS

A field experiment was carried out during rabi 2012-13 at Agricultural Research Station, Bhavanisagar, Tamil Nadu for assessing new formulation quizalofop-ethyl for weed control in irrigated groundnut. The soil was well drained red sandy loam, with low in available nitrogen (225 kg/ha), medium in available phosphorus (16.5 kg/ha) and high in available potassium (270 kg/ha). The soil was slightly acidic in nature with pH 6.8. The experiment was laid out in randomized block design with fourteen treatments and three replications.

Experiment treatments comprised different weed management practices viz., new formulation of quizalofop-ethyl (5% EC) at 37.5, 50, 75, and 100 g/ha, quizalofop-ethyl (targa super) at 37.5, 50 g/ha as early post-emergence application (EPOE) sprayed 15 days after sowing, pre-emergence (PE) application of pendimethalin at 1.0 kg/ha + hand weeding (HW) on 45 DAS, PE oxyfluorfen at 0.2 kg/ha + HW on 45 DAS, PE pendimethalin at 1.0 kg/ha + mechanical weeding (MW) on 45 DAS, PE oxyfluorfen at 0.2 kg/ha + MW on 45 DAS, PE pendimethalin at 1.0 kg/ha + layby application of oxyfluorfen at 0.2 kg/ha at 45 DAS, PE oxyfluorfen at 0.2 kg/ha + layby application of pendimethalin at 1.0 kg/ha at 45 DAS, hand weeding twice on 25 and 45 DAS and unweeded control.

Groundnut variety TMV (Gn) 13 suitable for cultivation in Tamil Nadu was used as a test variety for the study. The weed count was recorded species-wise using 0.5 m x 0.5 m quadrate from four randomly fixed places in each plot and expressed as number of weeds m-2. The weeds falling within the frames of the quadrant were collected, shade dried and later dried in hot-air oven at 70oC till a constant weight was obtained. The data on

Table-2 : Effect of weed management practices on plant height, leaf area index and dry matter production at 60 DAS in groundnut.

Treatments			Plant height (cm)	Dry matter production (kg/ha)
T_1	-	EPOE Quizalofop-ethyl 5% EC at 37.5 g/ha	30.8	3186
T_2	-	EPOE Quizalofop-ethyl 5% EC at 50 g/ha	31.6	3383
T_3	-	EPOE Quizalofop-ethyl 5% EC at 75g/ha	35.1	3835
T_4	-	EPOE Quizalofop-ethyl 5% EC at 100 g/ha	27.8	3456
T_5	-	EPOE Quizalofop-ethyl 5% EC (TS) at 37.5 g/ha	31.0	3102
T_6	-	EPOE Quizalofo p-ethyl 5% EC (TS) at 50 g/ha	30.7	3292
T_7	-	PE Pendimethalin at 1.0 kg/ha + HW on 45 DAS	32.3	3453
T_8	-	PE Oxyfluorfen at 0.2 kg/ha + HW on 45 DAS	32.5	3469
T_9	-	PE Pendimethalin at 1.0 kg/ha + MW on 45 DAS	32.3	3435
T_{10}	-	PE Oxyfluorfen at 0.2 kg/ha + MW on 45 DAS	32.6	3440
T_{11}	-	PE Pendimethalin at 1.0 kg/ha + layby Oxyfluorfen at 0.2 kg/ha on 45 DAS	32.4	3533
T_{12}	-	PE Oxyfluorfen at 0.2 kg/ha + layby Pendimethalin at 1.0 kg/ha on 45 DAS	32.5	3771
T_{13}	-	Hand weeding twice on 25 and 45 DAS	34.2	3594
T_{14}	-	Unweeded control	31.1	2059
SEd			1.3	188
CD (P=0.05)			2.6	386

Table-3 : Effect of weed management practices on yield and yield attributes of groundnut.

Treatments			No. of pegs/ plant	No. of matured pods/plant	Pod yield (kg/ha)
T_1	-	EPOE Quizalofop-ethyl 5% EC at 37.5 g/ha	16.00	7.80	1375
T_2	-	EPOE Quizalofop-ethyl 5% EC at 50 g/ha	18.93	9.87	1545
T_3	-	EPOE Quizalofop-ethyl 5% EC at 75g/ha	26.67	22.73	2168
T_4	-	EPOE Quizalofop-ethyl 5% EC at 100 g/ha	21.93	13.07	1676
T_5	-	EPOE Quizalofop-ethyl 5% EC (TS) at 37.5 g/ha	16.80	11.47	1435
T_6	-	EPOE Quizalofop-ethyl 5% EC (TS) at 50 g/ha	20.13	11.93	1585
T_7	-	PE Pendimethalin at 1.0 kg/ha + HW on 45 DAS	21.27	16.27	1720
T_8	-	PE Oxyfluorfen at 0.2 kg/ha + HW on 45 DAS	24.60	18.50	1845
T_9	-	PE Pendimethalin at 1.0 kg/ha + MW on 45 DAS	22.00	13.07	1565
T_{10}	-	PE Oxyfluorfen at 0.2 kg/ha + MW on 45 DAS	22.27	14.73	1705
T_{11}	-	PE Pendimethalin at 1.0 kg/ha + layby Oxyfluorfen at 0.2 kg/ha on 45 DAS	24.93	14.80	1910
T_{12}	-	PE Oxyfluorfen at 0.2 kg/ha + layby Pendimethalin at 1.0 kg/ha on 45 DAS	25.67	15.63	2012
T_{13}	-	Hand Weeding twice on 25 and 45 DAS	30.80	20.13	1927
T_{14}	-	Unweeded control	13.87	5.27	780
		SEd	1.89	1.11	129
		CD (P=0.05)	3.88	2.29	265

lower weed density, weed dry weight and higher weed control efficiency with post-emergence application of quizalofop ethyl in groundnut.

At 60 DAS, PE oxyfluorfen at 0.2 kg/ha + layby application of pendimethalin at 1.0 kg/ha recorded lower weed density, weed dry weight (9.67/m2 and 20.38 g/m^2). Similar results was reported by Chinnusamy (2007) where layby application of pendimethalin recorded lower weed density and weed dry matter in groundnut. Higher weed control efficiency was recorded in PE oxyfluorfen at 0.20 kg/ha + layby application of pendimethalin at 1.0 kg/ha recorded the highest weed control efficiency of 88.3% followed by PE pendimethalin at 1.0 kg/ha + layby application of oxyfluorfen at 0.20 kg/ha (82.2%). Similar findings were also revealed by Kanagam and Chinnamuthu (2009) who had reported that layby application showed higher weed control efficiency in groundnut.

Effect on crop : Early post-emergence application of quizalofop-ethyl 5% EC at 75 g/ha (35.1 cm) and hand weeding twice on 25 and 45 DAS (34.2 cm) recorded comparably higher plant height (Table-2). Dry matter

production was significantly higher in EPOE quizalofop-ethyl 5 % EC at 75 g/ha (3935 kg/ha) which was on par with PE oxyfluorfen at 0.2 kg/ha + layby application of pendimethalin at 1.0 kg/ha (3771 kg/ha) and hand weeding twice on 25 and 45 DAS (3594 kg/ha). Quizalofop-ethyl 5% EC at 75 g/ha as early post-emergence herbicide, hand weeding twice on 25 and 45 DAS and PE oxyfluorfen at 0.2 kg/ha + layby application of pendimethalin at 1.0 kg/ha recorded increased growth characters like plant height and dry matter production due to lesser interference of weeds and the minimum competition for the resources like light, nutrient, moisture and space during the early crop stage. Singh and Giri (2001) have observed that proper weed control was responsible for increase in plant height and dry matter production in groundnut.

Number of pegs per plant and matured pods per plant are the most important yield attributes that decide the pod yield. Lesser weed competition during critical periods of crop growth which in turn resulted in enhanced yield attributing characters. Early post-emergence application of quizalofop-ethyl 5% EC at 75 g/ha (26.67 and 22.73) and hand weeding twice on 25 and 45 DAS (30.80 and 20.13) showed higher number of pegs and matured pods (Table-3) as a result of better growing environment throughout the crop growth by proper check and lowering down the competition due to weeds.

Among the different weed management practices evaluated, EPOE quizalofop-ethyl 5% EC at 75 g/ha (2168 kg/ha), PE oxyfluorfen at 0.2 kg/ha + layby application of pendimethalin at 1.0 kg/ha (2012 kg/ha), hand weeding twice on 25 and 45 DAS (1927 kg/ha), PE pendimethalin at 1.0 kg/ha + layby application of oxyfluorfen at 0.2 kg/ha (1910 kg/ha) recorded significantly higher pod yield over other weed control treatments. These treatments were comparable between each other in terms of pod yield. Maximum pod yield was recorded with EPOE quizalofop-ethyl 5% EC at 75 g/ha (2168 kg/ha). This might be due to better control of grassy weeds over a longer period of time, thus providing a favourable environment for better growth and development of groundnut, leading to enhanced pod yield. These results were in confirmation with the earlier findings of Kumar et al. (2008) who had reported that significantly higher yield was recorded in post-emergence application of quizalofop-ethyl.

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INFLUENCE OF ORGANIC MANURES, MICRONUTRIENTS AND AM ON PLANT HEIGHT, ROOT LENTH, VOLUME, DRYWEIGHT AND THEIR RESIDUAL EFFECT OF MAIZE-SUNFLOWER CROPPING SYSTEM

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ABSTRACT

Field experiments were conducted to find out the influence of organic manures, micronutrients and arbuscular mycorrhiza (AM) on the productivity of maize-sunflower cropping system at Tamil Nadu Agricultural University, Coimbatore during 2011-12 and 2012-13. The experiment was laid out in split plot design and replicated thrice for maize during winter 2011-12 and 2012-13 and the same experiment after dividing each plot into two was laid out in split-split plot design and replicated thrice for sunflower during summer 2012 and 2013 to estimate the residual effects of organic manures. Among the organic manures poultry manure @ 5t ha^{-1} with RDF along with $ZnSO_4$ @ 37.5 kg ha^{-1} recorded (96.5, 211.3 and 243.2 cm at 30, 60 and 90 DAS, respectively).Poultry manure 5 t ha^{-1} and $ZnSO_4$ applied to maize with RDF to sunflower recorded higher plant height of (52.84, 116.5 and 155.7 cm at 30, 60 and 90 DAS, respectively) in maize during 2011-12 and 2012-13,recorded the higher root length of (27.88 cm) was recorded under poultry manure 5 t ha^{-1}, AM inoculated treatments recorded higher root length (27.84 cm) at harvest stage than the other micronutrient treatments. Among the mycorrhizal inoculation and micronutrients, AM inoculated plants recorded higher root volume (121.4 cm) than non inoculated plants and it was comparable with zinc sulphate. Inoculation of mycorrhiza had substantial effect on root dry weight. Mycorrhizal inoculated plants recorded higher root dry weight (813 kg) than the non mycorrhizal plants. During 2012, regarding organic manures, taller plants of sunflower (52.84, 116.5 and 155.7 cm at 30, 60 and 90 DAS, respectively) were recorded under poultry manure 5 t ha^{-1} applied to preceding maize. The micronutrients and AM, $ZnSO_4$ 37.5 kg ha^{-1} applied to preceding maize recorded taller plants (56.81, 104.4 and 150.9 cm at 30, 60 and 90 DAS, respectively) followed by TNAU MN mixture 30 kg ha^{-1} and AM to preceding maize. In 2012, with respect to organic manures, higher root length of sunflower (35.81 cm at harvest stage) was recorded under poultry manure 5 t ha^{-1} applied to preceding maize Among the micronutrients and AM, AM applied to preceding maize recorded higher root length of 31.58 at harvest stage followed by $ZnSO_4$ 37.5 kg ha^{-1} to preceding maize. 100 % RDF to sunflower recorded higher root length (31.03 at harvest stage). among the organic manures, higher root volume of sunflower (55.00 cc $plant^{-1}$ at harvest stage) was recorded under poultry manure 5 t ha^{-1} applied to preceding crop mycorrhiza inoculated to preceding maize recorded higher root volume of 50.11cc $plant^{-1}$ at harvest stage of the crop followed by $ZnSO_4$ 37.5 kg ha^{-1} and TNAU MN mixture. During 2012, among the organic manures, higher root dry weight of sunflower (409.4 g at harvest) was recorded under poultry manure 5 t ha^{-1} applied to preceding maize AM applied to preceding maize recorded higher root dry weight (391.6 g) at harvest followed by $ZnSO_4$ 37.5 kg ha^{-1} and TNAU MN mixture.

Key words : *Influence of INM maize, sunflower, residual organics, plant height, root length, volume and dry weight.*

Maize (*Zea mays* L.) is the third most important cereal crop next to rice and wheat, in the as well as in India. It is a versatile crop and it can be grown in diverse environmental conditions and has multiple uses. Besides its use as food, feed and fodder, maize is now gaining increased importance on account of its potential uses in manufacturing of starch, plastic, rayon, textile, adhesive, dyes, resins, boot polish, syrups, ethanol, etc In Tamil Nadu, maize is cultivated in an area of 0.30 million hectares with a production of 1.57 million tonnes and the productivity is 5173 kg ha^{-1} (Agricoop, 2011 - 12). By 2020 AD, the requirement of maize for various sectors will be around 100 million tonnes, of which the poultry sector demand alone will be around 31 million tones. Sunflower is India's premier oil seed crop that has made a significant role in yellow revolution of the country, to achieve self-sufficiency in vegetable oil. Among the oil seed crops, sunflower appears to be the most promising that not only fits well in the current cropping system but also yields oil of premium quality. The integrated nutrient management technology by using the biodegraded wastes along with chemical fertilizers has been found very effective in sustaining the production of crops on a long term basis in the sequential cropping system. Soil is the habitat for a vast complex and interactive community of the soil organisms whose activities determine the physical and chemical properties of the soil and in turn the growth and development of the crops. When specific microorganisms like Arbuscular mycorrhiza (AM) fungi are applied to seed or roots, they cause an alteration in the composition of rhizosphere and such alterations have positive implication on nutrient

Table-1 : Effect of organic manures, micronutrients and AM on plant height (cm) of maize

Treatment	Winter, 2011-12			Winter, 2012-13		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Organic manures (M)						
M_1 - RDF+ Farmyard manure @12.5 t ha^{-1}	82.4	179.3	207.8	75.2	206.0	235.4
M_2 - RDF+ Sericulture waste @ 5 t ha^{-1}	90.1	196.2	225.7	85.4	217.3	242.6
M_3 - RDF+ Poultry manure @ 5 t ha^{-1}	96.5	211.3	243.2	91.4	226.0	249.6
M_4 - RDF+ Goat manure @ 5 t ha^{-1}	85.6	186.3	211.4	74.6	209.4	237.6
M_5 - RDF alone (Control)	70.2	154.5	178.5	67.6	189.1	220.8
SEd	3.3	9.9	11.4	2.9	10.1	12.1
CD (P=0.05)	7.8	22.8	26.4	6.6	23.2	27.5
Micronutrients and AM (S)						
S_1 - AM @ 100 kg ha^{-1}	86.2	190.4	216.3	79.5	212.0	243.0
S_2 - $ZnSO_4$ @ 37.5 kg ha^{-1}	86.9	191.8	226.2	81.8	221.5	244.2
S_3 - TNAU MN mixture @ 30 kg ha^{-1}	86.2	189.2	220.8	80.5	213.7	241.6
S_4 - Control	80.6	170.7	190.1	73.6	190.1	220.0
SEd	2.7	9.0	10.5	2.2	9.2	10.2
CD (P=0.05)	5.5	18.5	22.0	4.5	19.0	21.6
Interaction	NS	NS	NS	NS	NS	NS

mobilization especially P and Zn hence the growth and development of plants.

MATERIALS AND METHODS

Field experiments were conducted during winter and summer seasons of 2011-2012 and 2012-2013 at Eastern block of Tamil Nadu Agricultural University, Coimbatore to investigate the influence of different organic manures with inorganic fertilizers on the growth and yield of maize and to assess their residual effect on the succeeding sunflower. The experiments were laid out in split plot design. In the main plot, four organic manures with RDF to maize *viz.*, FYM @ 12.5 t ha^{-1}, poultry manure @ 5 t ha^{-1}, goat manure@ 5 t ha^{-1}, sericulture waste@ 5 t ha^{-1} with a control (RDF only) and in the sub plot, four treatments *viz.*, AM, TNAU micro nutrient mixture and zinc sulphate were evaluated along with control. The treatments were replicated thrice. For the second crop individual plots were further divided into two for raising sunflower, one plot without RDF and one with 100 % RDF for sunflower.

The height of the plant was measured from the ground level to the tip of the top most leaf on 30, 60 and 90 DAS in five plants and mean of observations was arrived at and expressed in cm.

Root studies : Root length was measured from the base of the root to the tip of the primary root at the time of harvest. The mean values were calculated and expressed in cm. Water was poured into a clean measuring cylinder (nearly three fourth of its volume) and the level of water noted. To avoid parallax error, reading was taken at the lowest level of meniscus or curved surface of the liquid. A string was attached to the root and lowered into the water and the new level of water was noted. The difference in the above two readings was calculated and expressed as root volume in cm^3. The root samples were oven dried at 60 -70 °C for three days till a constant weight was obtained. The dry weight of root was recorded and expressed in g $plant^{-1}$.

RESULTS AND DISCUSSION

In maize among the organic manures poultry manure @ 5t ha^{-1} with RDF along with $ZnSO_4$ @ 37.5 kg ha^{-1} recorded higher plant height (96.5, 211.3 and 243.2 cm at 30, 60 and 90 DAS, respectively). Poultry manure 5 t ha^{-1} and $ZnSO_4$ applied to maize with RDF to sunflower recorded higher plant height of (52.84, 116.5 and 155.7 cm at 30, 60 and 90 DAS, respectively). In maize during 2011-12 and 2012-13,recorded the higher root length of (27.88 cm) was recorded under poultry manure 5 t ha^{-1}, AM inoculated treatments recorded higher root length (27.84 cm) at harvest stage than the other micronutrient treatments. Among the mycorrhizal inoculation and micronutrients, AM inoculated plants recorded higher root volume (121.4 cm) than non inoculated plants and it was comparable with zinc sulphate. Inoculation of mycorrhiza had substantial effect on root dry weight. Mycorrhizal inoculated plants recorded higher root dry weight (813 kg) than the non mycorrhizal plants. During 2012, regarding organic manures, taller plants of sunflower (52.84, 116.5 and 155.7 cm at 30, 60 and 90 DAS, respectively) were recorded under poultry manure 5 t ha^{-1} applied to preceding maize. The micronutrients and AM, $ZnSO_4$ 37.5 kg ha^{-1} applied to preceding maize recorded taller plants (56.81, 104.4 and 150.9 cm at 30, 60 and 90 DAS,

Table-3 : Residual effect of organic manures, micronutrients and AM applied to preceding maize and fertilizer level to sunflower on plant height of sunflower (cm).

Treatment	Summer, 2012			Summer, 2013		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Organic manures (M)						
M_1 - RDF+ Farmyard manure @ 12.5 t ha^{-1}	44.24	80.6	123.5	37.47	83.2	124.1
M_2 - RDF+ Sericulture waste @ 5 t ha^{-1}	50.65	100.5	141.2	51.20	106.3	145.1
M_3 - RDF+ Poultry manure @ 5 t ha^{-1}	52.84	116.5	155.7	60.83	121.9	159.4
M_4 - RDF+ Goat manure @ 5 t ha^{-1}	50.22	89.4	131.8	42.88	93.1	130.5
M_5 - RDF alone (Control)	33.45	69.8	116.4	32.42	76.2	117.7
SEd	1.61	3.7	3.1	2.31	3.8	3.44
CD (P=0.05)	3.70	8.5	7.2	5.32	8.6	7.94
Micronutrients and AM (S)						
S_1 - AM @ 100 kg ha^{-1}	42.13	88.86	124.1	43.34	92.1	130.0
S_2 - $ZnSO_4$ @ 37.5 kg ha^{-1}	56.81	104.35	150.9	51.75	109.9	152.6
S_3 - TNAU MN mixture @ 30 kg ha^{-1}	50.12	95.18	141.0	46.54	105.3	141.6
S_4 - Control	36.07	77.02	118.9	38.13	77.1	117.2
SEd	0.92	1.17	1.4	0.54	1.4	1.40
CD (P=0.05)	1.87	2.38	2.80	1.10	2.8	2.86
Fertilizer levels (F)						
F_0 - Control	44.91	88.40	130.6	42.60	92.8	132.1
F_1- 100 % RDF	47.65	94.30	136.9	47.28	99.5	138.6
SEd	0.10	0.19	0.2	0.15	0.2	0.2
CD (P=0.05)	0.21	0.39	0.4	0.31	0.5	0.5
Interaction	NS	NS	NS	NS	NS	NS

Table-4 : Residual effect of organic manures, micronutrients and AM applied to preceding maize and fertilizer level to sunflower on root length, root volume and root dry weight of sunflower at harvest.

Treatments	Summer, 2012			Summer, 2013		
	Root Length (cm)	Root Volume (cc $plant^{-1}$)	Dry weight (g)	Root Length (cm)	Root Volume cc $plant^{-1}$)	Dry weight (g)
Organic manures (M)						
M_1 - RDF+ Farmyard manure @ 12.5 t ha^{-1}	26.73	35.71	359.1	29.34	36.07	348.3
M_2 - RDF+ Sericulture waste @ 5 t ha^{-1}	31.54	44.23	379.0	35.16	47.14	367.9
M_3 - RDF+ Poultry manure @ 5 t ha^{-1}	35.81	55.00	409.4	38.16	52.42	391.8
M_4 - RDF+ Goat manure @ 5 t ha^{-1}	28.82	36.58	365.0	31.73	42.18	359.4
M_5 - RDF alone (Control)	22.61	28.10	333.8	27.43	32.41	337.2
SEd	1.02	2.23	5.9	0.89	0.69	5.0
CD(P=0.05)	2.34	5.15	13.6	2.05	2.05	11.5
Micronutrients and AM (S)						
S_1 - AM @ 100 kg ha^{-1}	39.32	50.11	391.6	39.29	54.30	393.1
S_2 - $ZnSO_4$ @ 37.5 kg ha^{-1}	31.58	41.37	375.3	34.01	45.62	368.1
S_3 - TNAU MN mixture @ 30 kg ha^{-1}	24.22	35.11	361.1	29.44	37.59	349.1
S_4 - Control	21.29	29.10	341.8	26.71	30.66	333.4
SEd	0.77	0.83	2.0	0.51	0.51	6.1
CD(P=0.05)	1.57	1.69	4.0	1.03	1.03	12.4
Fertilizer levels (F)						
F_0 - Control	27.18	37.00	348.5	30.30	39.95	341.0
F_1- 100 % RDF	31.03	40.85	386.4	34.42	44.14	380.9
SEd	0.13	0.13	1.3	0.14	0.14	3.9
CD(P=0.05)	0.26	0.26	2.6	0.27	0.27	7.8
Interaction	NS	NS	NS	NS	NS	NS

Table-2 : Effect of organic manures, micronutrients and AM on root length (cm), root volume (cm3plant-1) and root dry weight (gm) of maize at harvest.

Treatment	Winter, 2011-12			Winter, 2012-13		
	Root length (cm)	Root volume (cm^3 $Plant^{-1}$)	Root dry weight (gm)	Root length (cm)	Root volume (cm^3 $Plant^{-1}$)	Root dry weight (gm)
Organic manures (M)						
M_1 - RDF+ Farmyard manure @12.5 t ha^{-1}	24.72	114.0	725.4	25.71	105.8	802.2
M_2 - RDF+ Sericulture waste @ 5 t ha^{-1}	26.32	115.2	748.8	28.57	115.1	850.8
M_3 - RDF+ Poultry manure @ 5 t ha^{-1}	27.88	118.1	765.2	31.78	126.5	904.8
M_4 - RDF+ Goat manure @ 5 t ha^{-1}	25.46	113.9	727.6	26.19	109.6	821.1
M_5 - RDF alone (Control)	20.65	100.2	631.8	18.85	88.9	701.7
SEd	1.24	5.7	38.9	1.48	6.6	43.1
CD (P=0.05)	2.86	13.7	93.4	3.42	15.3	99.4
Micronutrients and AM (S)						
S_1 - AM @ 100 kg ha^{-1}	27.84	121.4	813.1	31.62	120.7	810.1
S_2 - $ZnSO_4$ @ 37.5 kg ha^{-1}	25.84	118.9	747.0	28.77	113.7	879.5
S_3 - TNAU MN mixture @ 30 kg ha^{-1}	24.14	110.9	678.7	24.58	106.2	829.8
S_4 - Control	22.21	98.0	640.1	19.91	96.2	745.2
SEd	0.95	4.9	17.5	2.07	3.2	26.6
CD (P=0.05)	1.93	10.0	35.7	4.23	6.6	54.3
Interaction	NS	NS	NS	NS	NS	NS

respectively) followed by TNAU MN mixture 30 kg ha^{-1} and AM to preceding maize.

In 2012, with respect to organic manures, higher root length of sunflower (35.81 cm at harvest stage) was recorded under poultry manure 5 t ha^{-1} applied to preceding maize. Among the micronutrients and AM, AM applied to preceding maize recorded higher root length of 31.58 at harvest stage followed by $ZnSO_4$ 37.5 kg ha^{-1} to preceding maize. 100 % RDF to sunflower recorded higher root length (31.03 at harvest stage). Among the organic manures, higher root volume of sunflower (55.00 cc $plant^{-1}$ at harvest stage) was recorded under poultry manure 5 t ha^{-1} applied to preceding crop mycorrhiza inoculated to preceding maize recorded higher root volume of 50.11cc $plant^{-1}$ at harvest stage of the crop followed by $ZnSO_4$ 37.5 kg ha^{-1} and TNAU MN mixture. During 2012, among the organic manures, higher root dry weight of sunflower (409.4 g at harvest) was recorded under poultry manure 5 t ha^{-1} applied to preceding maize AM applied to preceding maize recorded higher root dry weight (391.6 g) at harvest followed by $ZnSO_4$ 37.5 kg ha^{-1} and TNAU MN mixture. With regard to fertilizer levels, 100 % RDF to sunflower recorded higher root dry weight (386.4 g at harvest). The unfertilized control recorded the least root dry weight. The root dry weight recorded during 2013 also indicated similar trend as that of the previous year crop with regard to the organic manures, micronutrients, AM and fertilizer levels. The interaction effect was not significant during both the years of study.

The beneficial effect of poultry manure could be due to the supply of higher amount of both macro and micronutrient particularly nitrogen that helped in rapid cell division and cell elongation. These results are in accordance with the findings of Warren *et al.* (2006) and Farhad *et al.* (2009). Increase in plant height of maize due to poultry manure application as reported by Hugar and Palled (2008) also lends support to the present finding. In respect of micronutrients and AM, maize plants were taller with $ZnSO_4$ @ 37.5 kg^{-1} (S_2) and this was mainly due to the supply of zinc in required quantity as Zn is essentially required by maize for its growth and development. This result is in conformity with findings of Mahal *et al.* (2000), Sawarkar (2005), Kumpawat and Jat (2005) and Singh *et al.* (2006) who reported similar results.

Among the organic manures, poultry manure @ 5 t ha^{-1} with RDF recorded higher root length, root volume and root dry weight followed by sericulture waste @ 5 t ha^{-1} with RDF. This was due to balanced supply of all the macro and micro nutrients to maize crop. Similar findings were reported by Ahmed *et al.* (2014) and Javeed *et al.* (2013) in spring maize. Significant increase in root depth due to higher application rates of poultry manure as reported by Valenzuela *et al.* (2000) and Ahmad *et al.* (2009) in maize is concomitant to the present finding.The enhanced supply of P by mycorrhizal symbiosis has been

unequivocally demonstrated (Jakobsen *et al.* 1992; Asmah, 1995; Hetrick *et al.* 1996; Smith and Read, 1997; Subramanian *et al.*, 2006).

Plant height is an indication of growth performance of the crop and this was influenced by poultry manure applied to preceding maize due to prolonged slow N release from the poultry manure. Similar finding was reported by Rameshwar and singh (1997). Reyhan and Amiaslani (2006) observed that organic manure application led to remarkable difference in height, leaf and stem girth and leaf area in sunflower. Better crop growth recorded might be the result of adequate nutrition released by organics as earlier reported by Babaji *et al.* (2011). With regard to micronutrients and AM at early stage of crop growth, AM fungal inoculated plants showed an increase in root mass while the shoot masses were similar.

This might be attributed to the utilization of carbon for establishment of functional symbiosis as reported by Jakobsen and Rosendahl (1990).

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