The effect of fertilizer (NPK) on Infestation of Meloidogyne incognita on Cowpea, Vigna Unguiculata.(L.)

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Abstract

The effect of fertilizer (NPK) in single and double dose (N= 30,60kg/ha; P= 40, 80kg/ha and K= 35, 70kg/ha) was investigated on the infection of *Meloidogyne incognita* on cowpea, *Vigna unguiculata*, (L.) Walp. in field studies in a complete randomized design with five replicates each. The results showed that the single and double dose of the fertilizer (NPK) performed more or less in a similar fashion/ trend in almost all the treatments tested. Compared with the control (yield= 429gms, flowering = 44days, podding = 55days,vigour= 2.5, infection = 95% and galling= 82%) in both dosage, the fertilizer (NPK) or its component(s) showed higher grain yield (469-1184gms, i.e., 9.32-175.99%) which was significant with N (745-767gms), P (667-686gms), NP (801-1184gms) and NPK (910-1170gms) but not with P_2K_2 (395gms) in the double dose. The duration of flowering (32-41days), significant with only NPK (32days) and podding (42-53days), though not significant, were also shorter with better vigour, (3.0-4.8) which was significant with N (4.3-4.6), P(4.0-4.2), NP (4.0-4.6) and NPK (4.5-4.8). The infection (33-68%) and galling (30-70%) were also significantly reduced except K_1 (85%) in the single dose and K_2 (80%) in the double dose. Nitrogen showed better performance (yield= 743 - 767gms, flowering= 33-34days, podding =43-47days, vigour= 4.3-4.6, infection= 33-47% and galling= 42-49) than P (yield =667-686gms, flowering = 34-35days, podding = 45-46days, vigour= 4.0-4.2, infection= 53-54% and galling= 53-57%,) and K (yield = 469-503gms, flowering = 40-40days, podding= 50-53days, vigour = 3.0-3.0, infection = 68-85% and galling =70-80%,). In the same vein, any treatment combination with Nitrogen; NP (yield= 801-1184gms, flowering = 32-35days, podding = 42-46days, vigour= 4.0-4.6, infection = 37-39% and galling = 30-53%), NK (yield= 570-647gms, flowering= 36-38days, podding = 48-48days, vigour =3.0-3.3, infection = 59-60% and galling = 50-63) and NPK (yield = 910-1170gms, flowering = 32-32days, podding = 44-45days, vigour = 4.5-4.8, infection = 45-46% and galling= 47-55%,) showed better performance than treatments without -P and PK (yield =395-567gms, flowering = 35-41days, podding = 47-47days, vigour = 3.3-3.5, infection = 55-62% and galling = 55-60%,). Also P or any treatments with P- NP and NPK gave better performance whereas potassium or any treatment with potassium -NK and PK showed worst performance than treatments without K but when combined with NP as NPK, the performance was significantly improved in all the parameters. Doubling the dosage did not give any significant or commensurate advantage over the corresponding value in all the treatments tested though N_2P_2 (1184gms) gave a significant higher grain yield than N_1P_1 (801gms) and K_2 (68%) /N_2P_2 (30%) significant lower infection (K_1= 85%) and galling (N_1P_1 53%) than the corresponding treatment in the single dose.

Key words: Fertilizer, flowering/ podding, galling/ infection, grain yield, *Meloidogyne incognita.*

Introduction

Cowpea is a staple, drought tolerant food crop of significant economic importance world-wide, and the most important grain legume in Nigeria. The crop is grown traditionally by small scale farmers (98%) as mixed or relay crop in association essentially with cereals (90%), yielding about 0.30-0.50 tonnes/ha.

The world production is estimated at 4.5million metric tons on 14 million hectares of land (Singh *et al.,* 2002). Nigeria produces 2.833 million tonnes (Karmawa *et al*., 2002; Singh *et al*., 2002) with an average yield of 690kg/ha (FAO, 2007) which is about 30% of the potential yield. The country is the largest producer and consumer of the crop in the world (Nnanyelugo *et al*., 1997), accounting for 70% of the world production (Blade *et al.,* 1997; Singh *et al*., 2002) and supplying about 40% of the daily requirement of the people in Nigeria (Muleba *et al*., 1997).

The crop is grown as a pulse, vegetable, fodder (for live- stock feed) cover crop (for erosion control and environmental maintenance), cash crop, medicinal and soil ameliorant crop (can fix about 88kgN/ha), providing an inexpensive high quality protein (24%) (Bationo, *et al.*, 2000; Lambot, 2000).

However, the domestic supply of the crop falls short of the demand, accounting for a deficit of 518,400 metric tons (Caulibaly & Lowen berg – De Boer, 2002) which results in importation of 215, 040 metric tons from the neighboring countries mainly Niger (Kormawa *et al*., 2002).

The low grain yield of the crop partly accounts for the short- fall in supply, and is essentially due to infestation of pests and diseases (Isubikalu *et al*., 2000) which collectively inflict a grain yield loss of 50% in food crops (Cramer, 1967; Pimentel, 1983). Plant parasitic nematodes could also claim a global average yield loss of 12.3% on major food and fibres, valued at 77 billion dollars (Sasser & Freckman, 1987) or 25% on 60 different major cultivated crops in USA valued at 16,568 million dollars (Koenning *et al*., 1999)

The root knot nematodes are the most endemic and polyhagous, accounting for a yield loss between 10-100% (Jenkins & Taylor, 1967; Trudgill *et al.*, 2001) depending on the crop and locality, and a yield loss of 5-30% synergistically with pathogens (Sasser, 1989) and suppression of nodulation in legumes. (Taha & Samie, 1993.)

Of about more than 102 root knot nematodes (*Meloidogyne* spp.) identified (Luc *et al*., 1988; Olowe, 2009), only four (4) species, viz., *M. incognita* (Kofoid & White) Chitwood, *M. javanica* (Treub) Chitwood, *M. arenaria* (Neal) Chitwood and *M. hapla* Chitwood are considered the major pests of cowpea, accounting for a grain yield loss of 43% in West Africa (Sasser &Freckman, 1987). However, *Meloidogyne incognita* is the single most damaging world-wide (Ehler *et al*., 2002) with host range of about 3000 plant species (Trudgill & Block, 2001; Castognone Sereno, 2002).

The menace of these root knot nematodes could also be contained by fertilizer as an agricultural input. I inorganic fertilizers have been reported to influence the development and disease expression associated with plant parasitic nematodes directly or indirectly (Ismail & Saxena, 1976; Coyne *et al*.,2004; Irshad *et al*; 2006)

Although organic soil amendments like crop residues, manure or compost are useful as plant nutrition but they can not prevent nutrition mining, being a recycling process which can not compensate for nutrient exported through the crop production. As a result, use of external agricultural imputs such as fertilizer (NPK) becomes necessary for soil productivity (Bationo *et al*., 2002), and can suppress nematode more than manure (Forge, *et al* ., 2005) or compost (Hu & Qi, 2010)

The total number of plant parasitic nematodes could also be significantly correlated with the content of total Nitrogen, available Potassium and Phosphorus (Hu & Cao, 2008) and different nutrient regimes can also be correlated with the difficulties in penetration of pathogens (Huber, 1980) with infected plants suffering from deficiency of fertilizer.

Fertilizer might also increase the tolerance of plant to diseases (Melakaberhan *et al*., 1997), enhance nematode mortality, seed germination, plant growth/yield, water use efficiency (Bationo & Mokwunge, 1991; Sedogo, 1993 and nematicidal efficiency (Rodriguez – Kabba; 1986; Waceke *at al*., 2002).

Nematode infection could be significantly minimized by fertilizer (Akhtar, *et al*., 1998; Irshad *et al*., 2006; Dawar *et al*, 2007; Okada & Harada, 2007; Hu & Cao 2008; Hu & Qi, 2010). and nematode population suppressed (Egunjobi & Olaitan., 1986; Singh & Ram, 2004) with significant increase in plant growth and fodder yield from 1,700 to 8300kg/ha (Bationo *et al.*, 2002).

On cowpea, in field studies, fertilizer (NPK) decreased the population of *M. incognita* in root by 27.9%, galling by 20% and in soil by 55.3%. However, in green house studies, the decline was 40.8% in the root and 34.5% in the soil (Egunjobi & Olaitan, 1986)

In other nematodes too, fertilizer (NPK) suppressed the number of nematode populations (Zhad *et al*., 2003; Coyne *et al*., 2004; Baimey *et al*., 2006; Okada & Harada, 2007., Hu & Cao, 2008;), and doubling the fertilizer dosage further decreased the number of the nematodes (Khan *et al*., 1986; Akhtar, 1998).

In contrast, application of fertilizer (NPK) did not affect damage caused by the nematodes, *Radopholus similis* and *Helicotylenchus multicincus* on banana though gave positive yield (Smithson *et al*., 2001), and in a world survey, there was no correlation of occurrence of root knot nematodes with nitrogen, phosphorus or potassium. (Taylor *et al*., 1982).

With application of Nitrogen singly, root knot nematode development and also populations of other nematodes in both green house and field studies were suppressed (Badra & Khattab, 1980; Rodriguez – Kabana, 1986 Swain & Prasad, 1991) and yield/ biomes enhanced even when applied at low dosage of 1kg/ha (Smithson *et al*., 2001;.Bationo *et al*., 2002;

Crop yields increased with increase in Nitrogen (Akhtar *et al*., 1998), and application at 15kg/ha resulted in 0.39-9.95%, at 30kg/ha in 5.38-17.15% and at 95kg/ha in 9.75-17.69% increase in yield over the control with progressive suppression of root knot nematode development (Bado *et al*., 2011). Low dosage at 1kg/ha though gave positive effect on yield (Bationo *et al*., 2002 had no significant effect on damage (Smithson *et al*., 2001). Comparatively, Nitrogen gave greater increase in plant growth than P or K, and at 30kg/ha significantly increased the yield of cowpea (Rodriguez Kabana, 1986),

Phosphorus constitutes an essential need for legumes (Adetunji, 1995; Bationo *et al*., 2002) stimulating root/ plant growth / yield (Okeleye & Okelana, 1977; Kang-Nangju, 1983; Kolawole *et al*., 2002), enhancing seed germination (Mokwunye *et al*., 1986), promoting nodule formulation and reaction in the energy transfer (Isreal, 1987) and could triple the yield of cowpea slover (Bationo *et al*, 2002). Positive correlation has been observed between the phosphorus levels and the nematode population of *M.incognita* (Santth & Sundarababu, 1995). Population densities of nemaodes are also reduced and plant growth improved with phosphorus application (Waceke *et al*., 2002) Dosage at 180kg/ha lowered the population densities of *Heterodera sacchari* (Coyne *et al*., 2004), and at 25kg/ha, the yield was increased but there was no effect on nematode damage (Smithson *et al*., 2001. Phosphorus could also reduce the soil P^H which may adversely affect nematode reproduction (Plant *et al*., 1983).

Treatments with P have been shown to result in lesser reduction in nematode multiplication and galling than N but more than K (Akhar *et al.*, 1998). Root and shoot of cowpea could be retarded by 18.9-21.50% depending on the nematodes, and further increase of phosphorus resulted in increase in reduction of nematodes (Badra &Yousuf, 1979).

Potassium is noted to increase the reproduction capacity of several nematodes including *Meloidogyne, Rotylenchulus, Pratylenchus, Tylenchyorhycus* and also enhance plant growth (Rodriquez-Kabana, 1986), suppress root knot nematode development, galling and multiplication with high level dosage causing severe disease (Ismail & Saxena, 1976 (Badra &Yousif, 1979). Treatment with K could sometimes result in increase both in population of nematodes and plant growth (Badra & Khattab, 1980),
and application at 25kg/ha although had positive affect on cowpea yield but showed no effect on damage (Badra & Yousuf, 1979; Smithson *et al*., 2001). High application of K could result in higher fodder yield, triple slover production but lower grain production, (Bationo *et al*, 2002)

In Nigeria, pests (Rachie, 1985) and deceases (Remison, 1997) account for 80% of the grain yield loss of cowpea (Isubikabi *et al*., 2000). Insects account for 6-50%; fungi, 20-50%; Virus,40-80% and Weeds 50-80% (Jackai & Daoust, 1986; (Jackai & Adalla, 1997; Amusa & Adegbite 2006; Takim & Uddin,2010). Plant parasitic nematodes especially the root knot nematodes, *Meloidogne* spp are rated as one of the major factors limiting cowpea production with a wide host range of about 140 plant species (Wilson, 1962). Cowpea grain yield loss between 20-94% (Bridge, 1972; Cavaness, 1973; Ogunfowora, 1976, 1981; Babalola & Omitade, 1991;Olowe, 2009 is to be expected from infestation of root knot nematodes.

Information on reaction of nematodes to fertilizer (NPK) as an agricultural imput and soil amendment is meager. Studies on the alternative measure for root knot nematode, *Meloidogyne* spp., control had taken little cognizance of the possible use of fertilizer. The present study was, therefore, undertaken to determine the effect of fertilizer (NPK) in single and double dosage on the severity of root knot nematode, *M., incognita*, on cowpea.

Materials and Methods

The experiment was conducted on the farm of Department of Plant Science and Applied Zoology which was also infested with root knot nematode, *Meloidogyne incognita* as revealed by an earlier survey (Olowe, 2004). During the month of July, 2009, the farm was ploughed and divided into 75 flat plots of 5 × 6m (i.e., $30m^2$) each spaced at 1 meter apart. Fertilizer (NPK) at single (N=30kg/ha, i.e., $90gms/30m^2$; P= 40kg/ha, i.e., $120gms/30m^2$ and K= 35kg/ha, i.e., $105gms/30m^2$) and double (N\ 60kg/ha, i.e., 180gms/30m2; P_2= 80kg/ha, i.e., 240gms/ $30m^2$ and K= 70kg/ha, i.e., 210gms/ $30m^2$ and double (N_2 =60kg/ha, i.e., $180gms/30m^2$; P_2 = 80kg/ha, i.e., $240gms/30m^2$ and K_2 = 70kg/ha, i.e., $210gms/30m^2$) dose were applied to each plot in longitudinal furrows at 60cm apart within the plots to coincide with the rows for planting the cowpea seeds. The plots were arranged in a complete randomized design with each treatment replicated five times. Cowpea var. Ife brown seeds were planted at the rate of two seeds per hole at 30cm apart within the rows and 60cm apart between the rows. Two weeks after planting, the seedlings were thinned down to heathly one per hole.

As the plant growth progressed, days to 50% flowering and podding were determined. The vigour of the plants was also determined at 60days after planting (when the plants were fresh) on a scale index of 1-5 (1= Poor, i.e., stunted growth with yellow leaves, 2=Fair, i.e., retarded growth with yellow leaves, 3= Good, i.e., Normal full vegetative growth with yellowish green leaves, 4= Very good, i.e., normal full and strong vegetative growth with green leaves and 5= Excellent, i.e., normal full and very strong vegetation growth with full green leaves).

At harvest, the grain yield was determined. Thirty (30) plant stands were randomly picked from the inner rows of each plot and carefully up- rooted for rating for percentage of infection stands and root system galled.

Statistical Analysis

The data were subjected to ANOVA, and the means separated by Duncan multiple range test at P= 0.05. The data on percentage were log_{10} transformed before analysis and re-transformed for presentation.

RESULTS

The results are summarized in table 1.

SINGLE DOSE OF NPK ($N_1P_1K_1$) ON YIELD

All the treatments showed higher yields (469-910gms), i.e., 9.32-112.12%) than the control (429gms) with $N_1P_1K_1$ (910gms) giving the highest and K_1 (469gms) the least.

Nitrogen

The yield of Nitrogen (767gms) was not significantly different from that of Phosphorus (667gm) but significantly higher than that of Potassium (469gms). Nitrogen combined with N_1P_1as $N_1P_1K_1$ (910gms) gave significant higher yield than the components P_1 (667gms) and K_1 (409gms), and also treatments with nitrogen tended to show higher yields (N_1P_1= 801gms and $N_1P_1K_1$= 910gms) than treatments without (P_1=667gms, K_1=469gms and P_1K_1=567gms) except the low yield of the treatment with K_1 (N_1K_1= 647gms).

Phosphorus

The yield of phosphorus (667gms) was significantly higher than that of the control (429 i.e., 55.48.% but significantly lower than the yield of $N_1P_1K_1$ (910gms).Treatments with P_1 (N_1P_1=801gms, $N_1P_1K_1$=910gms) tended to show higher yields than treatments without (N_1=767gms, K_1= 469gms and N_1K_1=647gms) except the low yield of P_1K_1 (567gms).

Potassium

Potassium (469gms) gave the least yield which did not differ significantly from that of the control (429gms). Treatments with K_1 (N_1K_1= 647gms and (P_1K_1= 567gms) showed lower yields than treatments without (N_1= 767gms, P_1= 667gms, N_1P_1= 801gms but when combined with N_1P_1 as $N_1P_1K_1$ the yield was significantly improved (910gms).

DOUBLE DOSE OF NPK ($N_2P_2K_2$) ON YIELD.

Except for the low yield of P_2K_2 (395gms), the yields of other treatments (503-1184gms i.e 17.25-175.99%) were higher than that of the control (426gms) with N_2P_2 (1184gms) showing the highest yield followed by $N_2P_2K_2$ (1170gms) and P_2K_2 the least (395gms).

Nitrogen

Nitrogen (743gms) showed higher yield than P_2 (686gms) (though not significant) and K_2 (503gms) significantly. Nitrogen combined with P_2 as N_2P_2 (1184gms) or with P_2K_2 as $N_2P_2K_2$ (1170gms) gave significant higher yields than the components, N_2 (743gms), P_2 (680gms), K_2 (503gms) and N_2K_2 (570gms).

Phosphorus

Phosphorus (686gms) yielded significantly higher (59.91%) than the control (429gms). Combination of P_2 with K_2 as P_2K_2 (395gms) gave significant lower grain yield than the component P_2 (686gms), and also any combination with P_2 (N_2P_2= 1184gms and $N_2P_2K_2$= 1170gms) gave significant higher yields than those without (N_2= 743gms, K_2= 503gms and N_2K_2= 570gms) except the lower yield of combination with K_2 (P_2K_2= 395gms).

Potassium

Potassium gave a low yield of 503gms which was not significantly different from that of the control (429gms) but significantly lower than that of N_2 (743gms), and any combination with K_2 as N_2K_2 (570gms) or as P_2K_2 (395gms) always gave low yield but combined with N_2P_2 as $N_2P_2K_2$ gave significant very good yield (1170gms),significantly higher than the components N_2 (743gms), P_2 (680gms) or K_2 (503gms).

SINGLE DOSE OF NPK ($N_1P_1K_1$) ON PERCENTAGE GALLING

All treatments gave significant lower root galling (49-63%) than the control (82%) except the high galling by K_2(70%). The highest galling was by K_1 (70%) and the least by N_1 (49%).

Nitrogen

Nitrogen (49%) gave lower galling than P_1 (57%) (though not significant) and K_2 (70%) (significantly). Nitrogen (49%) or any combination with N_1 (N_1P_1= 53%, $N_1P_1K_1$= 55%) always tended to give lower galling than treatments without N_1 (P_1= 57%, K_1=70%, P_1K_1= 60%) except the high galling of combination with (N_1K_1= 63%).

Phosphorus

With Phosphorus, the galling (57%) was not significantly different from those of other treatments (53-63%) except the high galling by K_1 (70%) though combination with P_1 (N_1P_1= 53% and $N_1P_1K_1$= 50%) showed lower galling than treatments without (N_1= 70%, N_1K_1= 63%) except the low galling of N_1 (49%).

Potassium

Potassium showed highest galling (70%) as the control (82%). Treatments with K_1 (N_1K_1= 63% and P_1K_1= 60%) always showed higher galling than treatments without (N_1= 49%, P_1=57% and N_1P_1= 53%) but combined with P_1 as $N_1P_1K_1$ the incidence of galling was lowered (55%).

DOUBLE DOSE OF NPK ($N_2P_2K_2$) ON PERCENTAGE GALLING**.**

In doubling the dosage, all the treatments still had lower galling (30-80%) than the control (82%) with the highest galling by K_2 (80%)and the least by N_2P_2 (30%).

Nitrogen

Nitrogen (42%) showed galling which was lower than that of P_2 (53%) (though not significant) and K_2 (80%) (significantly), and combined with P_2 as N_2P_2 (30%) or P_2K_2 as $N_2P_2K_2$ (47%) showed significant lower galling than the component K_2 (80%). Nitrogen (42%) or treatments with N_2 (N_2P_2= 30%, N_2K_2= 50% and $N_2P_2K_2$= 47%) always gave lower galling that the treatments without (P_2= 53, K_2= 80% and P_2= 55%).

Phosphorus

Phosphorus (P_2) showed galling of 53% which was significantly lower than that of the control (82%) or K_2 (80%) and significantly higher than that of N_2P_2 (30%) but not significantly different from those of other treatments (42-55%). Combination of P_2 (53%) with K_2 as P_2K_2 (55%) gave galling which was significantly lower than that of the component K_2 (80%).

Potassium

Potassium (80%) showed significant higher galling than those of other treatments (30-55%) but was not significantly different from that of the control (82%). Combination with N_2 as N_2K_2 (50%) or with P_2K_2 as $N_2P_2K_2$ (55%) significantly reduced the galling.

SINGLE DOSE OF NPK ($N_1P_1K_1$) ON PERCENTAGE INFECTED STANDS

All treatments (33-85%) gave lower infection than that the control (95%). The highest infection was shown by K_1 (95%) and the least by N_1 (33%).

Nitrogen

Nitrogen (33%) gave infection significantly lower than that of P_1 (53%). Combined with P_1 as N_1P_1 (39%) showed galling which was lower than that of the component P_1 (53%) (though not significant). As N_1K_1 (59%), the infection was significantly higher than that of the component N_1 (33%) but significantly lower than that of the component K_1 (85%). Nitrogen (33%) or any combinations with N_1 (N_1P_1= 39% and $N_1P_1K_1$= 46%) tended to exhibit lower infection than treatments without (P_2= 53%, K_1= 85% and P_1K_1= 62%) except the high infection of N_1K_1 (59%)

Phosphorus

Phosphorus (53%) gave infection which was significantly lower than that of the control (95%) and K_1 (85%) but significantly higher than that of N_1 (33%). However, combined with K_1 as P_1K_1 (62%), the infection was also significantly lower than that of the component K_1 (85%) but not significantly different from infection of P_1 (53%). Phosphorus (95%) or any treatments with P_1 (N_1P_1=39% and $N_1P_1K_1$= 46%) gave milder infection than treatments without (K_1= 85% and N_1K_1= 59%) except the low infection of N_1 (33%) and high infection of P_1K_1 (62%)

Potassium

Potassium (85%) showed infection which was significantly higher than those of other treatments (33-62%) but not significantly different from that of the control (95%). Potassium (85%) or any treatments with K_1 (P_1K_1= 62% and N_1K_1= 59%) showed higher infection than the infection by other treatments (33-53%) but the infection was significantly tempered when combined with N_1P_1 as $N_1P_1K_1$ (46%).

DOUBLE DOSE OF NPK ($N_2P_2K_2$) ON PERCENTAGE INFECTED STANDS.

All treatments showed significantly lower infection (37-68%) than that of the control (95%) with K_2 giving the highest (68%) and N_2P_2 the least infection (37%).

Nitrogen

The infection of N_2 (47%) was lower than that of P_2 (54%) (though not significant) and K_2 (68%) (significantly). Combined with P_2 as N_2P_2 (37%), the infection was significantly lower than that of the component P_2 (54%), and with P_2K_2 as $N_2K_2P_2$ (45%) the infection was significantly lower than that of K_2 (68%). Nitrogen (47%) or any treatment with N_2 (N_2P_2= 37% and $N_2P_2K_2$= 45%) had milder infestation than treatments without (K_2= 68%, P_2K_2= 55%) except the high infection of N_2K_2 60%.

Phosphorus

The infection by phosphorus, (54%) did not differ significantly from those of other treatments (45-68%) except for the significant lower infection of N_2P_2 (37%) Phosphorus (54%) or treatments with P_2 (N_2P_2= 37% and $N_2P_2K_2$= 45%) had milder infestation that treatments without (N_2= 47%, K_2= 68% and N_2K_2= 60%) except for the high infection of P_2K_2 (55%)

Potassium

Potassium gave the highest infection (68%) and was significantly higher than that of N_2 (47%) Treatments with K_2 as N_2K_2= 60%, and P_2K_2= 45%) gave higher infection than treatments without (N_2= 47%, P_2= 54% and N_2P_2= 57% but combined with N_2P_2 as $N_2P_2K_2$ the infection was significantly lowered (45%).

SINGLE DOSE OF NPK ($N_1P_1K_1$) ON 50% FLOWERING

All the treatments (32-41days) had shorter duration than the control (44days) but were not significantly different from each other except the high duration (41days) by P_1 K_1 which gave the longest duration while $N_1P_1K_1$ gave the shortest duration (32days) which was significantly shorter than that of the control (44days).

Potassium (40days) or any treatments with K_1 (N_1K_1= 36days and P_1K_1= 41days) tended to show longer duration than the other treatments (32-35days) but combined with P_1K_1 as $N_1P_1K_1$ (32days), the duration was shortened.

DOUBLE DOSE OF NPK ($N_1P_1K_1$) ON 50% FLOWERING

The duration of all treatments (32-40days) were not significantly different from each other. Potassium showed the longest (40days) and N_2P_2 /$N_2P_2K_2$ the shortest (32days). The duration of N_2 (34days) and P_2 (35days) were shorter than that of K_2 (40days). Potassium (40days) or treatments with K_2 (P_2K_2= 38days and P_2K_2= 35days) showed higher duration than treatments without (N_2 = 34, P_2= 35days and N_2P_2= 32days) but combined with N_2P_2 as $N_2P_2K_2$ the duration was shortened (32days).

SINGLE DOSE OF NPK ($N_1P_1K_1$) ON DAYS TO 50% PODDING

The durations of all treatments (46-50day) were not significantly different from each other and that of the control (55days). Nitrogen (47days) was not significantly different from P_1 (46day) and K_1 50days. Potassium (50days) showed the longest and N_1P_1 (42days) the shortest duration but combined with N_1P_1 as $N_1P_1K_1$ the duration was shortened(44days).

DOUBLE DOSE OF NPK ($N_2P_2K_2$) ON 50% PODDING

All treatments showed shorter duration than the control (55days) but did not differ from each other (45-53days) and control (55%). Potassium showed the longest (53days) and N_2 (43days) the shortest duration.

Potassium (53days) or any treatment with K_2 (NK= 48day and P_2K_2= 47days) tended to show longer duration than treatments without (N_2= 43day, P_2= 45days and NP= 46days) but combined with N_2P_2 as $N_2P_2K_2$ the long duration was shortened (45days).

SINGLE DOSE OF NPK ($N_1P_1K_1$) ON VEGETATIVE VIGOR

All treatments (3.0-4.8days) showed better vigour index than the control (2.5) with $N_1P_1K_1$ giving the best vigour 4.8) and as K_1 the worst (3.0). Nitrogen (4.3) or any treatments with N_1 (N_1K_1= 4.6 and $N_1P_1K_1$= 4.8) gave better vigour than those without (P_1= 4.0, K_1= 3.0 and P_1K_1= 3.5) except the poor vigour by N_1K_1= (3.3).

The value of potassium (3.0) was the lowest among the treatments but combined with $N_1P_1K_1$ the vigour was significantly improved (4.8).

DOUBLE DOSE ON NPK ($N_2P_2K_2$) ON VEGETATIVE VIGOUR

All treatments (3.3-5.0) showed better vigour index than the control (2.5) with $N_2P_2K_2$ giving the best (4.5) and K_2 the worst (3.0).
Nitrogen gave value of 4.6 which was significantly better than that of K_2 (3.0) but was not significantly diferent from P_2 (4.2).Treatments with N_2 (N_2P_2= 4.0 and $N_2P_2K_2$= 4.5) were better in vigour than treatments without (K_2= 3.0, K_2= 3.3). Potassium (3.0) gave the worst vigour but when combined with N_2P_2 as $N_2P_2K_2$, the vigour was significantly better (4.5).

COMPARISION OF SINGLE WITH DOUBLE DOSE OF NPK

In comparing treatment by treatment in both single and double dose, all the tested parameters (yield, flowering, podding, vigour, infections and galling) showed no significant difference except the increase in yield in the double dose of N_2P_2 (1184gms) over the single dose (N_1P_1 = 910gms) and the lower infection of K_2 (68%) and galling of N_2P_2 (30%) over the corresponding single dose of infection (K= 85%) and galling (N_1P_1= 53%)

DISCUSSION

The results showed that the single and double dose application performed essentially the same in all the parameters examined. Higher grain yield, early flowering/ podding and better vigour were generally exhibited by all the treatments in both single and double dosage application as compared with the control. This suggests that the fertilizer (NPK) or its component (s) have stimulatory effect on the plant. leading to an enhancement of growth (Bationo Mokwunge, 1991; Sedogo, 1993) The suppression of infection and galling especially by N and P shows that the fertilizer has a nematicidal effect. Fertilizer has been observed to boost tolerance of plants to diseases, cause nematode mortality (Melakabertan *et al*., 1997), induce plant tissue to develop thicker cuticle and more sclenchyma to make penetration of nematodes difficult (Huber, 1980).

The reduction of galling of 53% by NPK compares favorably and essentially with the 40% reported by Egunjobi & Olaitan (1986) and largely agrees with the findings of other workers on other crops (Coyne *et al*., 2004; Baimey *et al*., 2006; Dawar *et al*., 2007; Okada & Harada, 2007; Hu & Cao, 2008) who reported that fertilizer (NPK) decreased root galling in plants.

The better performance of combination of all the three components together(NPK) in growth and infection/ galling than the individual component (s) in the single and double dose indicates that the combined effect of NPK is positively synergetic, and supports the wisdom of the farmers in applying the three components as a single entity.

The increase in yield by nitrogen (applied singly) more than those of P and K may be related to the absorption and utilization of the element for protein synthesis and seed production (Bado *et al* 2011) which would result in an advantageous increase in yield (Bationo & Ntare, 2000). This agrees with the observation of Rodriguez-kabana (1986).

The suppression of infection and galling by N also more than P and K might be due to the effect of nitrogenous metabolic products induced by the nematode which may accumulate and become phototoxic to the nematode (Rodriguez- Kabana, 1986). Concentration of root phenols has been observed to increase in nitrogen treated plants, and high amount of total phenol has been associated with higher nematode population with the phenols increasing as the nematodes decline, thereby acting as a kill/ inhibitor of nematode infection (Badra & Khattab, 1980). The Nitrogen could also exert a selective influence on the microbes antagonistic to the nematode, particular fungi (Morgan- Jones *et al* 1981; Ownley *et al*., 1983) to proliferate and reduce the nematode population in the soil. These factors might inter-play to account for the better performance of N than P or K and also for the treatments with N (Rodriguez- Kabana 1986; Akhtar *et.al*., 1998).

The significant higher yield and lower galling / infection of P than that of the control and K may be related to the enhancement of root growth which might spread through a greater volume of soil to diffuse nematode invasion and reduce galling and infection with consequential increase in yield. Phosphorus is considered the most limiting soil fertility factor for plant growth (Bationo *et al*., 2002) and is known to expand the absorptive capacity of the root system to make plant tolerant to pathogens (Cameron, 1986) and also to reduce the soil P^H which may adversely affect nematode reproduction (Plant *et al*., 1983). Coupled with this is the anabolic role played by P in the photosynthetic process and in storage of sugars and starches (Vander Heide, 1989) which may lead to increase in yield (Bationo *et al*., 2002). This factor may also account for good performance of treatments with P, and corroborates the findings of other workers (Kang- Nanju, 1983; Akhtar *et al*, 1998; Kolawole *et al*., 2002). However, it contradicts the report of Osiname (1978) who observed that phosphorus only enhanced nodulation and content of the leaves and stem of plants with no effect on nematode damage and also that of Smithson *et al*., (2001) who recorded only increase in yield but no nematode damage also. These discrepancies may be attributed to differences in crop intra/ inter- specific variation or the dosage or brand of fertilizer applied among other biotic and abiotic factors. The higher yield but lower galling infection shown by NP over the single N or P may be an indication of synergetic effect of N and P together.

The worst performance of K with highest galling and infection with lowest yield can be attributed to enhanced increase in nematode population and egg production resulting in severe damage on crops (Badra & Khattab; 1980) Bationo *et al*., 2002.

The poor performance of K singly or in combination with other treatments, N or P (which exhibited better performance when applied singly) suggests that the effect of K is dominant over N or P. Potassium may disrupt /distort/impair the anabolic processes that enhance increase in growth and suppression of diseases. The fact that when K is combined with N and P together as NPK, the performance was improved indicates that the adverse effect of K is neutralized or overridden by combination with N and P together. This may also make the plant so strong as to withstand invasion/ infection

The non-significance of most of the treatments in the double dose application of the fertilizer compared with the corresponding treatments in the single dose application may suggest that the double dose has no economic advantage or that the dosage is not high enough to effect a significant or commensurate value.

Though soil fumigation is highly effective, it has a limitation as majority of fumigants/ nematicides are no longer available and even costly and difficult to apply properly under the prevailing situations. More importantly, subsistence farmers with small holdings and poor financial resources can least afford the cost of nematicides. Thus, a simple, economic and feasible approach to nematode management holds promise for the future, and NPK if well applied may lend itself to effective nematode management and improvement in yield also.

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