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Discovering Thoughts, Inventing Future

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By Vinsoun Millogo, Michel Kéré, Ouda Sanfo, Toundji Olivier Amoussou, Timothy Harrigan, Robert Burdick & Ajit Srivastava

Nazi Boni University

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Abstract- The availability and sustainability of water in rural areas are significant challenges facing agricultural producers in the Sahelian zones. Maize-legume intercropping with a mulch cover for water conservation with drip irrigation is a promising production practice for conserving water, increasing productivity and improving soil health. A randomized complete block trial with 04 replications and 08 treatments was established in Sonsongona (11.2522°N, 4.4559°W), a village located west of Bobo-Dioulasso, Burkina Faso. Means separation by analysis of variance (ANOVA) was with RStudio 1.2.1335 software at the 5% threshold according to the Newman-Keuls test. The mulched treatments significantly affect soil moisture, maize growth, weed growth, and important maize yield attributes. Mulched maize plant height was not significantly greater than mulched treatments at 60 days after planting, but the average grain yield was 4,479.00 ± 39.70 kg/ha for maize + peanut + mulch compared to 3,288.00 ± 328.75 kg/ha for maize seeded without mulch or a legume. Overall, combined with legumes, mulching increased maize yield, conserved soil moisture, and helped control weeds. Combining mulch with legumes reduces weeding labor costs by controlling grass cover.

Keywords: drip irrigation, conservation agriculture, maize, day after planting (DAP) mulching, maize-legume intercropping, burkina faso.

Résumé- La disponibilité de l'eau agricole de manière durable est un l'un des challenges auquel fait face à la plupart des pays de la zone Sahélienne. En effet, parmi les défis à relever, il y a l'utilisation rationnelle de l'eau disponible à travers l'irrigation goutte à goutte et la gestion durable des sols à travers l'agriculture de conservation. C'est dans ce contexte que cette étude a été réalisée à Sonsongona à l'Ouest du pays avec pour objectif d'amélioration de la situation alimentaire des ménages vulnérables par la mise en place d'un système de culture de maïs en saison sèche en association avec des légumineuses adaptées au système d'irrigation goutte à goutte. Un essai en bloc complètement randomisé à quatre (04) répétitions et huit (08) traitements a été installé. Ce système d'irrigation goute-à-goute avec pompage solaire a été conçu et installé par l'équipe du consortium de la mécanisation agricole appropriée en 2017. Les données ont été soumises à l'analyse des variances (ANOVA) à l'aide du logiciel RStudio 1.2.1335. La comparaison des moyennes a été faite à l'aide du test Newman-Keuls au seuil de probabilité 5%. Les résultats ont montré que les traitements avec paille ont eu des effets significatif sur l'état d'humidité du sol, la croissance du maïs, le taux d'enherbement et sur certains composants du rendement du maïs. Les traitements avec paille engendraient, quant à elles, une bonne croissance, mais non significative en hauteur (Maïs + arachide + paille : 240,30 ± 8,68 cm ; Maïs + niébé + paille: 242,30 ± 8,10 cm ; Maïs + mung bean + paille : 242,30 ± 7,75 cm et Maïs + paille sans légumineuses : 242,20 ± 8,46 cm) et en diamètre (Maïs + arachide + paille : 3,58 ± 0,83 cm ; Maïs + niébé + paille : 2,76 ± 0,05 cm ; Maïs + mung bean + paille: 2,80 ± 0,13 cm et Maïs + paille sans légumineuses: 2,87 ± 0,13 cm) des plants de maïs au 60è JAS. Le rendement grain du maïs était de 4 479,00 ± 39,70 kg/ha pour Maïs + niébé + paille contre 3 288,00 ± 328,75 kg/ha. De façon générale, le paillage combiné aux légumineuses améliore l'état d'humidité du sol et permet de contrôler l'enherbement. La croissance des plants de maïs a été meilleure lorsque le paillage est combiné aux légumineuses. Le mung bean a un effet sur la croissance supérieure aux autres légumineuses. Les résultats ont montré une amélioration non significative du rendement du maïs. Le niébé a un effet sur le rendement supérieur aux autres légumineuses. La combinaison du paillage aux légumineuses permettrait de réduire le coût des travaux en contrôlant l'enherbement des parcelles et permettant ainsi de diversifier la production.

Mots clés: irrigation goutte à goutte, agriculture de conservation, maïs, jour après semi (JAS), paillage, association céréales-légumineuses, burkina faso.

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I. Introduction

Agricultural sector contribute to food security, economic growth and reduce poverty and food insecurity in sub-Saharan Africa. Agriculture

accounts for more than 25% of GDP in African countries and is the primary source of income and employment for at least 65% of the African population (Heno et al., 2006). Agriculture contributes up to 30% of the regional GDP and employs more than 55% of the rural population (CEDEAO, 2015). In Burkina Faso, agriculture contributes 40% of the GDP and employs 86% of the active population (MAHRH, 2011). However, Burkina Faso faces chronic food insecurity because of adverse agro-climatic conditions and significant soil degradation leading to low crop yields. Agriculture is primarily a rainfed livestock-cropping system (Sonou, 2010). Demographic pressures and the subsequent loss of fallow land has further amplified this trend (Coulibaly, 2012). Therefore, increasing agricultural productivity is a significant challenge for Burkina Faso.

Irrigation can help to create additional household income beyond the rainy seasons by focusing on high-value cereals crops such as maize. Drip irrigation increases agricultural productivity by reducing the vulnerability of plants to water stress since the difficulties associated with irrigation are limited to the irrigation frequency and the insufficient subsoil water by capillary action (Tapsoba, 2016, Millogo et al., 2021). Among the current irrigation methods, drip irrigation appears to be the most efficient (Sonou, 2010; Millogo et al., 2021). It provides uniform distribution and efficient water use for the plant (Millogo et al., 2021). The efficiency of drip irrigation is 90% to 95% compared to 40% to 45% for gravity irrigation and 80% for sprinkler irrigation (Sonou, 2010).

Despite water management efforts, declining soil fertility remains another problem many farms face (Coulibaly et al., 2012a). Continuous land use leads to low carbon and declining soil organic stocks (Coulibaly et al., 2012a). This land utilization, combined with the transfer of nutrients for crops such as maize, is one factor that maximizes the risk of declining soil fertility with the significant consequence of lower crop yields.

Given the importance of legumes in nitrogen fixation, their association with cropping systems as alternatives to nitrogen fertilization appears to be a reasonable approach. According to Coulibaly et al. (2012a); Crasky et al. (2003), legume systems provide sustainable soil fertility management through atmospheric nitrogen (N) fixation. By improving the nitrogen status of the soil, legumes increase cereal yields (Azontondé, 1993; Rusimanhodji et al., 2012; Coulibaly et al., 2017a; Coulibaly et al., 2017b). The maize and legume association represents an alternative in managing risks and uncertainties for farmers faced with global changes (Coulibaly et al., 2017a).

Despite their importance in cropping systems, there is little evidence of their impact on dry season cereal production. For legumes to become an essential part of cropping systems, it is necessary to look at their effects on dry season cereal production. There is a need to investigate the intercropping and mulching effects on maize productivity in the dry season under drip irrigation. This study is aimed to sustainably intensify the cropping system productivity of smallholder farmers by establishing a drip irrigation system to grow crops and legumes during the dry season. The solar panel drip irrigation system was designed, implemented, and tested in 2018 by the USAID-funded Appropriate Scale Mechanization Consortium (ASMC) team. A paper was published on its water distribution and use efficiency (Millogo et al., 2021). The objectives of the study reported in this paper were to study effects of intercropping maize with legume combined with mulching on dry season maize yield and soil water parameters.

II. Materiel and Methods

a) *Overview of the study area*

This study was conducted at Sonsongona village (04°16' West longitude and 11°60' North latitude) of (Figure 1A), located 20 km from Bobo-Dioulasso city centrum nearby Bobo-Dioulasso-Banzon corridor. The village is part of the commune of Bobo-Dioulasso in the Houet province, which, together with the provinces of Tuy and Kénédougou, are the Hauts-Bassins Region. Sonsongona is located in the southern Sudanian climate with annual rainfall between 800 and 1200 mm. It is characterized by a dry season (November to April) during which the Harmattan blows and a rainy season (April to November) dominated by the monsoon. The inter-annual variability of rainfall ranges from 723.7 mm in 2017 to 1303.8 mm in 2018 with 51 and 70 rainy days, respectively (Figure 1B). The intra-annual variation is marked by a total annual rainfall of 1303.8 mm on 70 rainy days (Figure 1C). The soil at the study site is sandy loam on the surface and clayey at depth with an acid pH and low humus content (Table 1).The vegetation is a wooded savannah divided into three strata: woody, shrubby and herbaceous, with open forests on the shallows and along the river (Guinko and Fontès, 1995).

Table 1: Physical and chemical property of the soil

Sable	Limon	Argile	Humus	pH
62,66	2166,	15,67	Faible	6,8

Source: (Yé, 2018; Millogo et al., 2021).

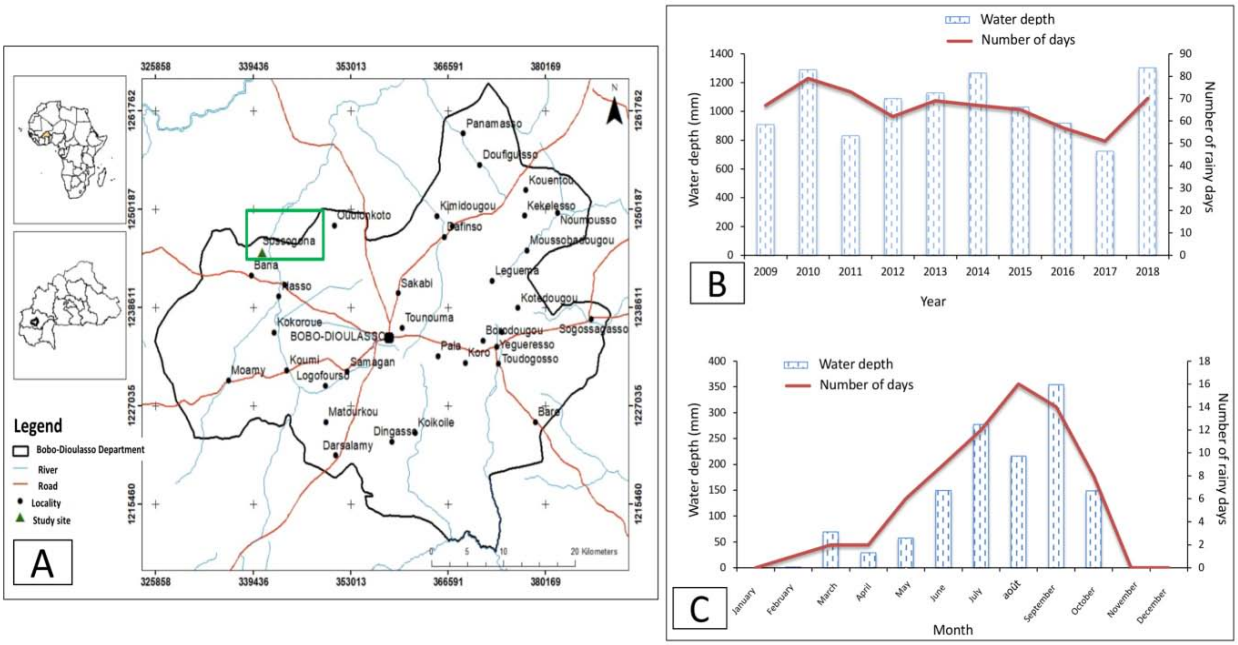

Figure 1: Map of the study site (A) with the variation in rainfall over the last ten years (B) and during the year 2018 (C)

b) Irrigation system description

The irrigation system used was an ASMC prototype design and implemented in 2017 to deliver water homogeneity (Millogo et al., 2021). Major components of the system included a well, a solar planel, a PS-200 HR 07 solar pump, a water tower with a capacity of 2000 L tower, and an irrigation kit consisting of ramps, valves, volumetric meters, emitter lines, and integrated emitters.

c) Technical and plant materials

The soil sampling equipment included: a hand auger, a metric square; a weighing scale; a bag; an oven; a hand hoe, a sprayer; a caliper; and metric measuring tape. The plant material consisted mainly of maize (*Zea mays*), cowpea (*Vigna unguiculata*), groundnut (*Arachis hypogeae*), and mung bean (*Vigna radiata*). The maize variety Streat Resistant N°21 (SR21) with an intermediate cycle (95 days) was used. Its planting-male flowering and planting-maturity cycles are 59 days after planting (DAP) and 95 days to seed, respectively. The height of the plant was 180 cm with an ear insertion height of 90 cm. This variety tolerates some common diseases such as helminthosporiasis, rust and is resistant to MSV (Maize Streat Virus). It is a white maizeed-toothed variety with a potential 5.1 t/ha (Sanou, 2009). This variety is suitable for areas with rainfall between 900 and 1200 mm of water per year. The cowpea was variety KVx442-3-25SH (Komcalé), a precocious and drought-tolerant variety with a potential yield of 1.5 to 2 tonnes/ha (CNS, 2014). The peanut variety Fleur11, was chosen because of its short cycle with a potential yield of 2.5 tons/ha (CNS, 2014). The mung bean was species *Vigna Radiata.*

d) Fertilization

We used both organic and mineral fertilizers. 320 g of NPK (14-23-14) and urea 320 g (46%) were used for mineral fertilizers in equal amounts in all plots (320 g). Mineral fertilizers were used under a special authorization to meet only farmer standard practices. For organic fertilization, cattle manure was incorporated before soil preparation (10 t/ha). Soil covering/mulching was with rice straw. The straw was applied at the rate of 3 tons/ha with a thickness of 5 cm.

e) Experimental Design

The experimental design was a randomized complete block with a total area of 637 m^2 (Figure 2). Two factors were considered in the study. The first factor was the crop associated with four levels (groundnut, cowpea, mung bean, and legume-free). The second factor was soil cover with two patterns (without mulch and with mulch). The trial consisted of 04 replicates and 08 treatments. Each plot was 16 m^2 (5.7 m × 2.8 m). The inter-block and inter-plot spacings were 1 m and 0.4 m, respectively. The treatments were: (i) MwRP: Maize + Peanut with Rice Straw, (ii) MfRP: Maize + Peanut without Straw, (iii) MwRC: Maize + Cowpea with Rice Straw, (iv) MfRC: Maize + Cowpea without Straw, (v) MwRMb: Maize + Mung bean with Rice Straw, (vi) MfRMb: Maize + Mung bean without straw, (vii) MwLf: Maize + Straw without legumes, (viii) MfLf: Maize without Straw without Legumes.

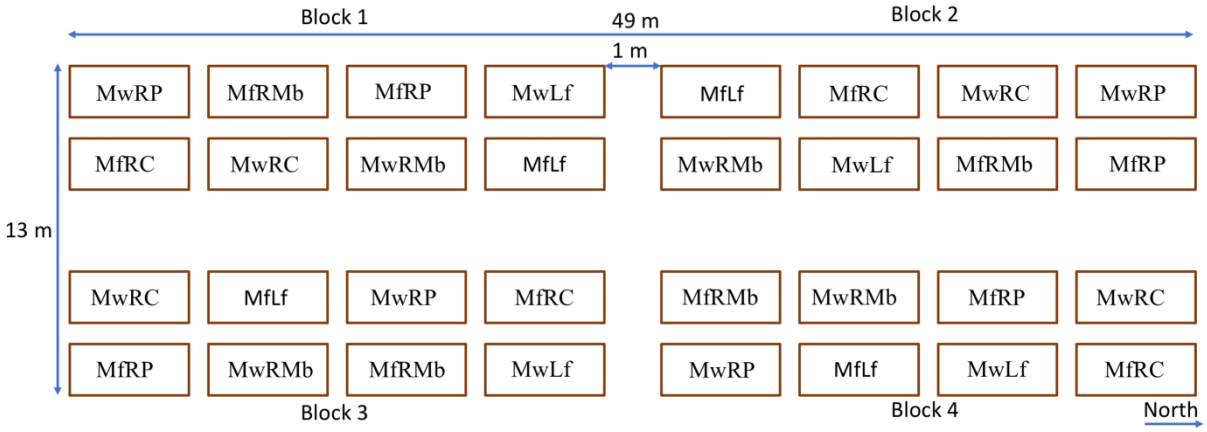

Figure 2: Illustration of the experimental design. MwRP: Maize with Rice straw combined with Peanut; MfRP: Maize free of rice Straw combined with Peanut; MwRC: Maize with Rice straw combined with Cowpea; MfRC: Maize free of Rice straw combined with Cowpea; MwRMb: Maize with Rice straw combined with Mung bean; MfRMb: Maize free of Rice straw combined with Mung bean; MwLf: Maize with Rice straw and Legume-free; MfLf: Maize free of rice straw and Legume-free

f) Implementation

Seedbed preparation consisted of ploughing to a depth of 15 to 20 cm, then crumbling with a hoe. The drip irrigation lines were installed was set up following the soil preparation. Planting operations were by hand. Maize was planted on February 13 at 0.8 m row spacing and 0.2 m inter-hills spacing at a seeding rate of two seeds per hill, followed by an emergence seedling thinning to one plant/hill. Cowpea, groundnut, and mung bean were planted two weeks after maize in the inter-row area at a rate of two seeds/hill for cowpea and mung bean and one seed/hill for groundnut. Cowpea and mung bean were planted at 40 cm spacings and groundnut at 20 cm spacings. Other operations such as weeding, fertilization, and irrigation were carried out jointly to maintain the crops. Hoe weeding was carried out on the 14th, 29th, and 44th day after planting (DAP) and manual weeding on the 60th DAP. Organic fertilization consisted of applying cattle manure before ploughing by spreading. The mineral fertilization, i.e., the application of chemical fertilizers, was carried out following the technical itinerary of maize. The NPK fertilizer (14-23-14) was applied at 200 kg/ha on the 15th DAP. Urea (46%) was applied in two fractions. The first dose of urea (100 kg/ha) was applied on the 30th DAP, and the second dose (50 kg/ha) was applied on the 45th DAP. The water was applied by drip irrigation to meet the water needs of the main crop, maize (60 to 65 m^3), according to Millogo et al. (2021).

g) Data collection and statistical analysis

For soil moisture determination, soil samples were taken for three strati of 0 to 10 cm, 10 to 20 cm, and 20 to 30 cm. Soil sampling was done following the diagonal of each plot, and 03 specific locations were identified for these samples. For each stratus, a composite sample was taken and transported to the laboratory. Samples of 200 g wet weight were put in the oven at 105°C for 48 hours. Samples were collected on the 7th, 21st, 35^{th,} and 49th DAP. The soil moisture was determined after drying the samples in the oven. The moisture content was calculated using equation one below in Table 1.

Rice straw cover was evaluated in a 1 m^2 sample placed randomly on the diagonal of each plot. It was estimated as a percentage at the 14th, 29^{th,} and 44th DAP. The parameter was assessed using a visual rating scale ranging from 1 (no cover) to 9 (complete cover) as described by Marnotte (1984). Measurement of growth parameters of maize plants included plant height and crown diameter. Plant height was measured on 06 randomly selected plants (Kouelo et al., 2017) in the plot at the 15th, 30th, 45th, and 60th DAP. This height was measured from the collar to the ligule of the last well-developed leaf of the plant. The collar diameter was measured on six randomly selected plants (Kouelo et al., 2017) for height measurements using a caliper at the 15th, 30th, 45^{th,} and 60th DAP.

Several maize yield components were measured at maturity: 1,000-grain weight, grain yield, number of grains/ears (calculated from the number of radius/ear and the number of grains/radius), number of ears, straw yield, and stalk weight. All the plots' maize plants were cut at the crown level at 124 DAP for the measurements. The ears were harvested, then dried and shelled by hand. The seeds were weighed using an electronic balance. The values were extrapolated to the hectare (kg/ha) according to formula number 2 (Table 1). After shelling, the stalks were weighed and extrapolated to one hectare using formula number 3 (Table 1). The weight of 1,000 grains was by manually counting 1,000 grains and then weighing using an electronic scale. The number of ears of maize was by direct counting of all the ears of maize in the plot and

then extrapolated to the hectare according to formula number 4 (Table 1). After drying, six ears were randomly selected for counting the number of rows per ear and the number of grains per row used to determine the number of grains per ear. The number of grains per ear was by formula 5 (Table 1). The straw was weighed on a scale to obtain the different fresh weights. Samples of 100 g were taken and dried in an oven at 105°C for 72 hours to determine dry weights. The total straw production was determined by formula 6 (Table 1). All values were extrapolated to represent kg/ha according to formula number 7 (Table 1). The data were then subjected to an analysis of variance (ANOVA) using RStudio 1.2.1335. The separation of the means was made at the 5% threshold according to the Newman-Keuls test.

Table 2: Formulas used for the various calculations

Number	Computation formulae
1	Moisture Content (%) = (((wet weight-container weight)-(dry weight-container weight))/(dry weight-container weight))×100
2	Yield (kg/ha) = ((Pu ×10000))/(10 (m^2) ×1000) Where, Pu: grain weight of the useful parcel in grams; 10000: the surface area of one hectare in m^2 , 10 m^2 the surface area of the useful parcel, 1000: the equivalent of one kilogram in grams
3	Stalk weight (kg/ha) = ((WRuP×10000))/(10 (m^2) ×1000) Where, WRuP: Weight of the Rafles of the Useful Plot, 10000: the surface area of one hectare in m2 , 10 m^2 the surface area of the useful plot, 1000: the equivalent of one kilogram in grams
4	Number of ears/ha = ((NEPu ×10000))/(10 (m^2)) Where, NEuP: number of ears of the useful plot, 10000: the surface area of one hectare in m^2 , 10 m^2 the surface area of the useful plot
5	Number of grains/ears = (number of grain/radius)×(number of radius/ear)
6	DW (g) = DWS/FWS×TFW Where, DW: dry weight; DWS: dry weight of the sample; FWS: fresh weight of the sample; TFW: total fresh weight
7	Straw yield (kg/ha) = (WS ×10000)/10 (m2) ×1000 Where, WS: the weight in grams of the straw of the useful plot, 10000: the surface area of one hectare in m^2 , 10 m^2 the surface area of the useful plot, 1000: the equivalent of one kilogram in grams

III. Results

a) Effects of mulching and legumes on soil moisture

The effects of mulching and legumes on soil moisture content (Figure 3) showed that moisture content varied from one treatment to another depending on the measurement depth and production period. At the 7th DAP (Figure 3A), soil weight moisture varied in the overlying horizons from 11.25 ± 2.69% (MfLf) to 13.38 ± 2.35% (MwRC). In the middle and deep horizons, the same trends were observed. All mulched land plots (MwRP, MwRC, MwRMb, MWLF) had improved soil moisture compared to bare soil (MfLf). At this level, no significant difference was detected among treatments.

From the 21st DAP (Figure 3B), better moisture levels are with the MwRP (16.00 ± 0.41%) and MwRC (16.00 ± 0.54%) treatments in the overlying horizons. At this level, all treatments with mulch (MwRP, MwRC, MwRMb, MWLF) had better moisture content than treatments without mulch (MfRP, MfRC, MfRMb, and MfLf). These moisture levels varied significantly between treatments ($p < 0.05$). Treatments (MfRP, MfRC, MfRMb) had no significant effect on soil moisture compared to bare soil (MfLf). In the medium and deep horizons, the different treatments did not significantly affect soil moisture levels.

At the 35th DAP (Figure 3C), the moisture content ranged from 15.00 ± 0.5% (MfLf) to 18.12 ± 1.14% (MwRMb) and the moisture content did not vary significantly between treatments. The greatest moisture levels were in the mulched plots. The moisture content in plots under legume cover (MFRP, MFRC, and MfRMb) was greater compared to plots under mulch alone (MWLF) and without mulch (MfLf). The combination of mulch and legumes (MwRP, MwRC, and MwRMb) improved soil moisture compared to bare soil (M) or legumes alone (MfRP, MfRC, and MfRMb).

The greatest moisture levels were on the 49th DAP (Figure 3D) in the surface zones with the combined legume and mulch treatments (MwRP, MwRC, and MwRMb). Legumes (MfRP, MfRC, and MfRMb) improved soil moisture compared to simple mulch (MWLF) and bare soil (MfLf) at these same depths. In the middle and deep horizons, no significant difference was found. However, the effect of mulching and

legumes on moisture remains better than on bare soil. In fact, there is no significant difference between the differents horizons but the soil moisture is better on mulchning and legumes treatments than bare soil.

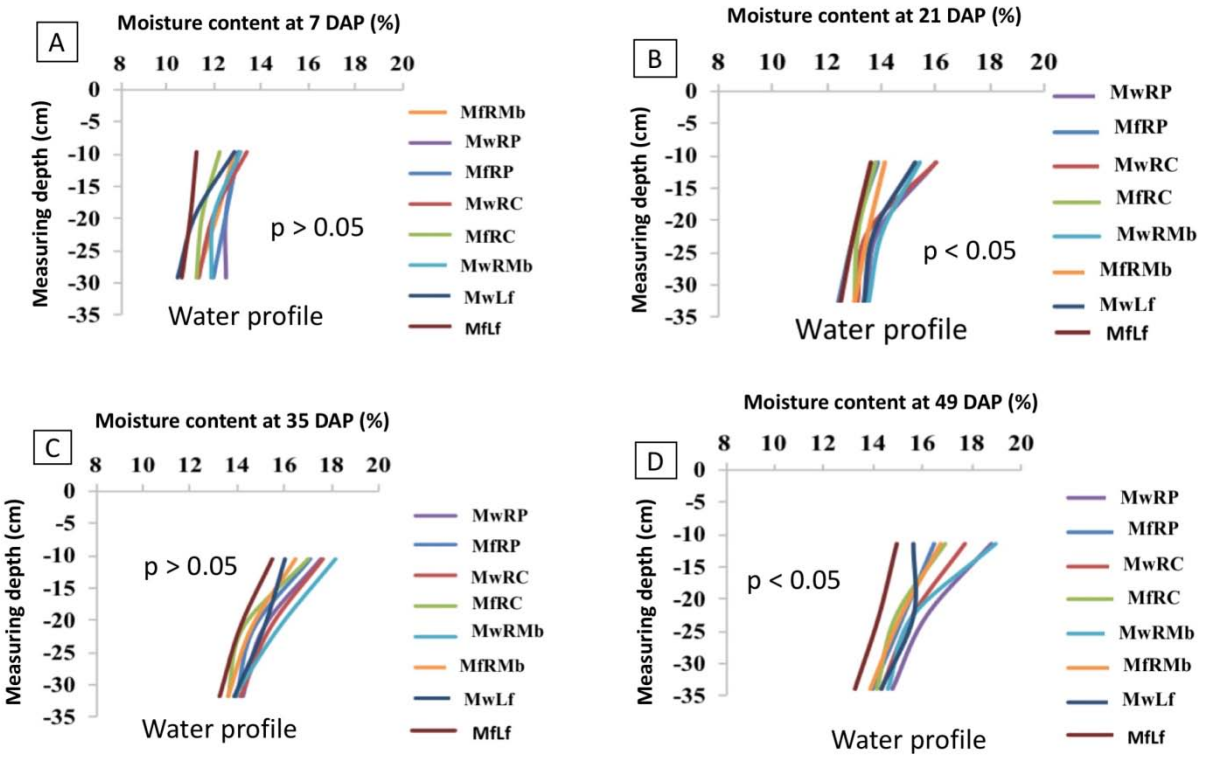

Figure 3: Effect of legumes and mulching on soil moisture status. MwRP: Maize with Rice straw combined with Peanut; MfRP: Maize free of rice Straw combined with Peanut; MwRC: Maize with Rice straw combined with Cowpea; MfRC: Maize free of Rice straw combined with Cowpea; MwRMb: Maize with Rice straw combined with Mung bean; MfRMb: Maize free of Rice straw combined with Mung bean; MwLf: Maize with Rice straw and Legume-free; MfLf: Maize free of rice straw and Legume-free

b) Effects of mulching and legumes on grass cover

The specific and combined effects of mulch and legumes on plot grass cover differed between treatments and between assessment periods (Table 2). A significant difference ($p < 0.05$) was detected among no mulching and mulching treatments. In fact, the assessment of the straw cover rate at 14 DAP showed that the highest value was with the MwRP treatment (22.5 ± 3.23%) and the lowest value with the MfRMb treatment (15.00 ± 00%). At this level, all the plots that were mulched (MPAb: 22.5 ± 3.23%, MwRC: 20.00 ± 3.53%, MwRMb: 18.75 ± 2.39%, and MWLF: 18.75 ± 1.25%) had a higher grass cover rate than the plots without mulching (MfRP, MfRC, MfRMb, and MfLf).

As in the 14th DAP, data on grass cover rates also differed between treatments. The MwRC treatment resulted in the highest grass cover rate (24.16 ± 3.40%), and the lowest value was with the MWLF treatment (17.50 ± 1.44%). At this level, treatments combining legume-mulch (MwRP: 22.66 ± 3.53%, MwRC: 24.16 ± 4.40% and MwRMb: 23.75 ± 3.15%) gave higher values compared to simple mulching (MWLF: 17.50 ± 1.44%). However, bare soil (MfLf: 20.00 ± 2.89%) had a higher grass cover rate than plots with legume only (MfRP: 18.75 ± 2.39%, MFRC: 18.75 ± 3.75% and MfRMb: 17.50 ± 2.50%). No significant differences were detected among different treatments.

At the 42nd DAP, the grass cover rate also differed from one treatment to another. The highest value was with the MfRMb treatment (32.50 ± 3.88%), and the lowest value was with the MfRP treatment (22.91 ± 4.73%). Peanut in combination with mulch had a better effect on the grass cover rate (MwRP: 25.83 ± 6.25%) compared to the other combinations (MwRC: 29.58 ± 1.57%) and MwRMb (28.75 ± 6.71). At this stage, weed control is essential regardless of the treatment. No significant difference was found between treatments.

On the 56th DAP, the grass cover rate varied according to treatments. Significant differences were detected among mulching and no mulching treatments. The effect on the grass cover rate is much greater with the MwRMb treatment (17.5 ± 1.44%) than with the MfLf treatment (27.50 ± 5.81%). At this production stage, all treatments combining legumes with mulch significantly affected the weed cover (MwRP: 18.75 ± 1.25%, MwRC: 20.00 ± 2.04%, and MwRMb: 17.5 ± 1.44%). Similarly, legumes associated solely with maize had an effect on

weed cover (MfRP: 21.25 ± 1.25%, MfRC: 23.75 ± 3.15% and MfRMb: 22.50 ± 1.44%) compared to mulch (MWLF: 26.25 ± 1.25%) and bare soil (M: 27.50 ± 5.81%).

Table 3: Combined effects of mulching and legumes on weed growth

Weed growth					
Treatments		14 DAP	28 DAP	42 DAP	56 DAP
MwRP	M	22.50[a]	21.66[a]	25.83[a]	18.75[c]
	SE	3.23	3.53	6.25	1.25
MfRP	M	17.50[a]	18.75[a]	22.91[a]	21.25[b]
	SE	2.5	2.39	4.73	1.25
MwRC	M	20.00[a]	24.16[a]	29.58[a]	20.00[c]
	SE	3.53	3.4	1.57	2.04
MfRC	M	18.75[a]	18.75[a]	25.41[a]	23.75[b]
	SE	2.39	3.75	3.75	3.15
MwRMb	M	18.75[a]	23.75[a]	28.75[a]	17.50[c]
	SE	2.39	3.15	6.71	1.44
MfRMb	M	15.00[a]	17.50[a]	32.50[a]	22.50[b]
	SE	-	2.5	3.88	1.44
MWLF	M	18.75[a]	17.50[a]	26.66[a]	26.25[a]
	SE	1.25	1.44	2.63	1.25
MfLf	M	17.50[a]	20.00[a]	29.91[a]	27.50[a]
	SE	2.5	2.89	5.81	5.81
Freedom Degree		7	7	7	7
p-value		0.618	0.631	0.882	0.005
Significance		NS	NS	NS	**

*M: mean; ES: standard error; NS: non-significant ($p > 0.05$), **: $p < 0.01$. Numbers with the same superscript in the same column were not statistically different at the 5% threshold. MwRP: Maize with Rice straw combined with Peanut; MfRP: Maize free of rice Straw combined with Peanut; MwRC: Maize with Rice straw combined with Cowpea; MfRC: Maize free of Rice straw combined with Cowpea; MwRMb: Maize with Rice straw combined with Mung bean; MfRMb: Maize free of Rice straw combined with Mung bean; MwLf: Maize with Rice straw and Legume-free; MfLf: Maize free of rice straw and Legume-free*

c) *Effects of mulching and legumes on maize height growth*

The specific and combined effects of mulch and legumes on maize plant height growth are presented in Table 3. The height varied from one treatment to another. At 15th DAP, the average height of maize plants ranged from 4.72 ± 0.11 cm (MfRP) to 5.69 ± 0.06 cm (MwRP). The greatest growth was with the MwRMb treatment (5.52 ± 0.28 cm). All treatments with mulching improved maize height (MwRMb: 5.52 ± 0.28 cm, MwRP: 5.69 ± 0.06 cm, MwRC: 5.64 ± 0.45 cm and MWLF: 5.27 ± 0.25 cm) compared to treatments without mulch (MfRP: 4.72 ± 0.11 cm, MfRMb: 4.70 ± 0.21 cm and M: 4.95 ± 0.25 cm) except for the MfRC treatment (5.34 ± 0.28 cm). However, there were no significant differences between treatments.

At 30th DAR, the height also ranged from 21.71 ± 0.89 cm (MfRC) to 26.88 ± 1.10 cm (MwRP), although no significant difference between treatments was detected. At this stage of growth, the greatest growth was when the soil was covered with straw mulch. All crops under mulch had more growth (MwRP: 26.88 ± 1.10 cm, MwRC: 24.29 ± 1.10 cm, MwRMb: 24.75 ± 0.97 cm and MWLF: 24.36 ± 1.93 cm) compared to crops not mulched (MfRP: 22.35 ± 0.46 cm; MfRC: 21.71 ± 0.89; MfRMb: 21.94 ± 0.89 cm and M: 22.12 ± 1.00 cm).

At the 45th DAP, although no significant differences were detected, maize plant height growth varied among treatments. The most growth was with the MwRMb treatment (97.17 ± 7.77 cm), and the least growth was with the MfLf treatment (76.33 ± 6.31 cm). As at 30th DAP, maize plants had good growth on the mulched plots (MwRP: 95.12 ± 5.12 cm, MwRC: 88.29 ± 5.40 cm, MwRMb: 97.17 ± 7.77 cm and MWLF: 93.29 ± 7.08 cm) compared to unmulched plots (MFRP: 81.54

± 4.10 cm, MfRC: 82.25 ± 4.74 cm, MfRMb: 79.21 ± 1.18 cm and MfLf: 76.33 ± 6.31 cm). Combining legumes with maize did not significantly affect maize growth, but maize tended to be taller when mulched than in bare soil (MfLf: 76.33 ± 6.31 cm).

At 60th DAP, the average height of the maize plants ranged from 215.40 ± 8.42 cm (MfLf) to 242.30 ± 8.10 cm (MwRC) and 242.30 ± 7.75 cm (MwRMb). Mulching lead to greater growth (MwRP: 240.30 ± 8.86 cm, MwRC: 242.30 ± 8.10 cm, MwRMb: 242.30 ± 7.75 cm and MWLF: 242.20 ± 8.46 cm) than unmulched (MfRP: 220.60 ± 2.58 cm, MfRC: 223.60 ± 10.48 cm, MfRMb: 223.50 ± 6.34 cm and MfLf: 215.40 ± 8.42 cm). However, legumes (MfRP: 220.60 ± 2.58 cm, MfRC: 223.60 ± 10.48 cm, MfRMb: 223.50 ± 6.34 cm) had a significant effect on maize plant growth compared to bare soil (M: 215.40 ± 8.42 cm). In combination with mulch, cowpea (MwRC: 242.30 ± 8.10 cm) and mung bean (MwRMb: 242.30 ± 7.75 cm) gave a better effect on growth. However, no significant differences were detected.

Table 4: Combined effects of mulching and legumes on maize height growth

Treatments		Maize height (cm)			
		15 DAP	30 DAP	45 DAP	60 DAP
MwRP	M	5.69[a]	26.88[a]	95.12[a]	240.30[a]
	SE	0.06	1.1	5.12	8.86
MfRP	M	4.72[a]	22.35[b]	81.54[a]	220.60[a]
	SE	0.11	0.46	4.1	2.58
MwRC	M	5.64[a]	24.29[a]	88.29[a]	242.30[a]
	SE	0.45	1.1	5.4	8.1
MfRC	M	5.34[a]	21.71[b]	82.25[a]	223.60[a]
	SE	0.4	0.89	4.74	10.48
MwRMb	M	5.52[a]	24.75[a]	97.17[a]	242.30[a]
	SE	0.28	0.98	7.77	7.75
MfRMb	M	4.70[a]	21.94[b]	79.21[a]	223.50[a]
	SE	0.21	0.89	1.18	6.34
MWLF	M	5.27[a]	24.36[a]	93.29[a]	242.20[a]
	SE	0.25	1.93	7.08	8.46
MfLf	M	4.95[a]	22.12[b]	76.33[a]	215.40[a]
	SE	0.25	1	6.31	8.42
Freedom Degree		7	7	7	7
p-value		0.1	0.034	0.093	0.172
Significance		NS	*	NS	NS

*M: mean; ES: standard error; NS: non-significant ($p > 0.05$), *: $p < 0.05$. Numbers with the same superscript in the same column are not statistically different at the 5% threshold. MwRP: Maize with Rice straw combined with Peanut; MfRP: Maize free of rice Straw combined with Peanut; MwRC: Maize with Rice straw combined with Cowpea; MfRC: Maize free of Rice straw combined with Cowpea; MwRMb: Maize with Rice straw combined with Mung bean; MfRMb: Maize free of Rice straw combined with Mung bean; MwLf: Maize with Rice straw and Legume-free; MfLf: Maize free of rice straw and Legume-free*

d) Effects of mulching and legumes on maize plant diameter

The specific and combined effects of mulch and legumes on maize plant diameter growth are presented in Table 4. The values varied depending on the stage of growth. At the 15th DAP, maize plant diameter values ranged from 0.46 ± 0.05 cm (MfRC) to 0.58 ± 0.04 cm (MWLF). The largest maize plant diameter tended to be in the mulched plots (MwRP: 0.53 ± 0.03 cm, MwRC: 0.48 ± 0.04 cm, MwRMb: 0.49 ± 0.05 cm and MWLF: 0.58 ± 0.04 cm). However, no significant difference was detected.

At 30 DAP, plant diameter varied significantly ($p < 0.001$) from 1.90 ± 0.09 cm (MfLf) to 2.45 ± 0.10 cm (MWLF). The greatest plant diameter was with the MWLF treatment: 2.45 ± 0.10 cm. All plots mulched plots resulted in more growth (MwRP: 2.41 ± 0.01 cm, MwRC: 2.25 ± 0.08 cm, MwRMb : 2.31 ± 0.15 cm and

MWLF: 2.45 ± 0.10 cm) compared to plots without mulch (MfRP: 1.97 ± 0.09 cm, MfRC: 2.03 ± 0.05 cm, MfRMb: 1.93 ± 0.06 cm and M: 1.90 ± 0.09 cm). However, legumes had asignificant effect on maize plant diameter growth compared to bare soil (MfLf: 1.90 ± 0.09 cm).

At the 45th DAP, plant diameter did not vary significantly among treatments. The largest diameter was with the MwRMb treatment (3.09 ± 0.10 cm), and the smallest diameter was with the MfRC treatment (1.78 ± 0.09 cm). When the soil was mulched, there was greater growth (MwRP: 2.95 ± 0.12 cm, MwRC: 3.03 ± 0.10 cm, MwRMb: 3.09 ± 0.10 cm and MWLF: 2.96 ± 0.50 cm) relative to the unmulched soil (MfRP: 2.90 ± 0.13 cm, MfRC: 1.78 ± 0.09 cm, MfRMb: 2.94 ± 0.50 cm and MfLf: 2.77 ± 0.08 cm). At this stage of growth, the presence of legumes influenced plant diameter (MfRP: 2.90 ± 0.13 cm, MfRC: 2.78 ± 0.09 cm, and MfRMb: 2.94 ± 0.15 cm) compared to pure maize (MfLf: 2.77 ± 0.08 cm). At the 60th DAP, no significant difference was detected among treatments.

Table 5: Effects of mulching and legumes on maize diameter growth

Collar diameter (cm)					
Treatments		15 DAP	30 DAP	45 DAP	60 DAP
MwRP	M	0.53[a]	2.41[a]	2.95[a]	3.58[a]
	SE	0.03	0.01	0.12	0.83
MfRP	M	0.45[a]	1.97[b]	2.90[a]	2.58[a]
	SE	0.03	0.09	0.13	0.05
MwRC	M	0.48[a]	2.25[a]	3.03[a]	2.76[a]
	SE	0.04	0.08	0.1	0.05
MfRC	M	0.46[a]	2.03[b]	2.78[a]	2.48[a]
	SE	0.05	0.05	0.09	0.11
MwRMb	M	0.49[a]	2.31[a]	3.09[a]	2.80[a]
	SE	0.05	0.15	0.1	0.13
MfRMb	M	0.46[a]	1.93[b]	2.94[a]	2.73[a]
	SE	0.02	0.06	0.15	0.18
MWLF	M	0.58[a]	2.45[a]	2.96[a]	2.87[a]
	SE	0.04	0.1	0.5	0.13
MfLf	M	0.47[a]	1.90[b]	2.77[a]	3.45[a]
	SE	0.04	0.09	0.08	0.83
Freedom Degree		7	7	7	7
p-value		0.447	0	0.392	0.546
Significance		NS	***	NS	NS

*M: mean; ES: standard error; NS: non-significant ($p > 0.05$), ***: $p < 0.001$. Numbers with the same superscript in the same column are not statistically different at the 5% threshold. MwRP: Maize with Rice straw combined with Peanut; MfRP: Maize free of rice Straw combined with Peanut; MwRC: Maize with Rice straw combined with Cowpea; MfRC: Maize free of Rice straw combined with Cowpea; MwRMb: Maize with Rice straw combined with Mung bean; MfRMb: Maize free of Rice straw combined with Mung bean; MwLf: Maize with Rice straw and Legume-free; MfLf: Maize free of rice straw and Legume-free.*

e) *Effects of mulching and legumes on maize grain and biomass*

The effects of mulching and legumes on yield components are shown in Table 5. The different components were similar. Maize stalk weights ranged from 738.50 ± 148.83 kg/ha to 1,054.00 ± 23.47 kg/ha. The best weight of stalks was with the MwRMb treatment (1,054.00 ± 23.47 kg/ha). All mulch treatments improved maize stalk weight (MwRP: 927.80 ± 81.39 kg/ha, MwRC: 941.50 ± 32.59 kg/ha, MwRMb: 1,054.00 ± 23.47 kg/ha and MWLF: 1,015.20 ± 65.35 kg) compared to treatments without mulch (MfRP:

869.00 ± 26.11 kg/ha, MfRC: 750.00 ± 107.74 kg/ha, MfRMb: 738.50 ± 148.83 kg/ha and M: 920.50 ± 18.77). Legumes did not improve stalk weight ($p > 0.05$).

For the number of ears per hectare, values ranged from 26,000.00 ± 3,135.82 ears/ha (MfRC) to 38,500.00 ± 1,658.51 ears/ha (MwRMb). Here, no difference was detected among treatments. Table 5 showed that 1,000 grains weight ranged from 287.80 ± 1.89 kg (MfRMb and MfLf) to 303.50 ± 8.92 kg/ha (MwRMb). The greatest 1,000 grains weight was with the mung bean-mulch treatment (MwRMb: 303.50 ± 8.92 kg/ha). No significant difference was detected among treatments for 1,000 grain weight.

Grain yield varied among treatments. The greatest grain yield was with the MwRP treatment (4,479.00 ± 39.70 kg/ha), and the lowest yield was with the MfLf treatment (3,288.00 ± 328.75 kg/ha). All mulch treatments improved grain yield (MwRP: 4,479.00 ± 39.70 kg/ha, MwRC: 4,385.00 ± 61.94 kg/ha, MwRMb: 4,435.00 ± 447.32 kg/ha and MWLF: 4,105.00 ± 267.98 kg/ha) compared to treatments without mulch (MfRP: 3,884.00 ± 58.95 kg, MfRC: 3,430.00 ± 491.59 kg/ha, MfRMb: 3,735.00 ± 641.86 kg/ha and MfLf: 3,288.00 ± 328.75 kg/ha). Treatments combining legumes (MfRP, MfRC, and MfRMb) also improved this parameter compared to bare soil (MfLf). The analysis of variance did not reveal significant differences among treatments.

The highest amount of dry matter was with the MWLF treatment (7,026.00 ± 1,084.00 kg/ha), and the lowest value was with the MfRMb treatment (4,316.00 ± 447.50 kg/ha) with no significant difference detected among treatments (Table 5). The number of grains per ear ranged from 518.00 ± 12.32 grains/ear (MfRP) to 600.10 ± 10.80 grains/ear (MwRMb). All treatments combining legume-mulching improved the number of grains/ear (MwRP: 597.50 ± 19.51 grains/hair, MwRC: 574.70 ± 13.40 grains/ear and MwRMb: 600.10 ± 10.80 grains/ear) compared to simple mulching (MWLF: 557.00 ± 19.28 grains/ear) and bare soil (M: 564.60 ± 30.75 grains/ear). Legumes with maize (MfRP: 518.00 ± 12.32 grains/ha, MFRC: 535.60 ± 21.57 grains/ha and MfRMb: 525.40 ± 14.96 grains/ha) did not significantly ($p > 0.05$) improve grain count compared to mulching alone (MWLF: 557.00 ± 19.28 grains/ha) and bare soil (M: 564.60 ± 30.75 grains/ha).

Table 6: Yields and yield components as a function of mulching and legumes

Treatments		Stalk weight (kg/ha)	Number of ears/ha	Thousand Grains Weight(g)	Total Grain Weight (kg/ha)	Straw yield (kg/ha)	Number of grains/ears
MwRP	M	927.80[a]	29,500.00[a]	298.20[a]	4,479.00[a]	5,988.00[a]	597.50[a]
	ES	81.39	2,101.59	6.43	39.7	935.7	19.51
MfRP	M	869.00[a]	31,500.00[a]	288.80[a]	3,884.00[a]	4,535.00[a]	518.00[c]
	ES	26.11	1,892.97	3.2	58.95	489.51	12.32
MwRC	M	941.50[a]	32,750.00[a]	293.20[a]	4,385.00[a]	5,772.00[a]	574.70[a]
	ES	32.59	3,119.16	6.42	61.94	241.95	13.4
MfRC	M	750.00[a]	26,000.00[a]	297.50[a]	3,430.00[a]	5,464.00[a]	535.60[c]
	ES	107.74	3,135.82	6.03	491.59	468.26	21.57
MwRMb	M	1 054.00[a]	38,500.00[a]	303.50[a]	4,435.00[a]	5,064.00[a]	600.10[a]
	ES	23.47	1,658.31	8.92	447.32	623.81	10.8
MfRMb	M	738.50[a]	28,750.00[a]	287.80[a]	3,735.00[a]	4,316.00[a]	525.40[c]
	ES	148.83	4,385.11	1.89	641.86	447.5	14.96
MWLF	M	1 015.20[a]	36,250.00[a]	298.20[a]	4,105.00[a]	7,026.00[a]	564.60[b]
	ES	65.35	1,652.02	2.69	267.98	1,084.00	19.28
MfLf	M	920.50[a]	31,750.00[a]	287.80[a]	3,288.00[a]	5,330.00[a]	527.00[c]
	ES	18.77	2,780.14	1.89	328.75	455.07	30.75
Freedom Degree		7	7	7	7	7	7
p-value		0.064	0.074	0.357	0.175	0.143	0.036
Significance		NS	NS	NS	NS	NS	*

*M: mean; ES: standard error; NS: non-significant ($p > 0.05$), *: $p < 0.05$. Numbers with the same superscript in the same column are not statistically different at the 5% threshold. MwRP: Maize with Rice straw combined with Peanut; MfRP: Maize free of rice Straw combined with Peanut; MwRC: Maize with Rice straw combined with Cowpea; MfRC: Maize free of Rice straw combined with Cowpea; MwRMb: Maize with Rice straw combined with Mung bean; MfRMb: Maize free of Rice straw combined with Mung bean; MwLf: Maize with Rice straw and Legume-free; MfLf: Maize free of rice straw and Legume-free*

IV. Discussion

a) Effects of mulching and legumes on soil moisture

Mulching improved soil moisture status compared to bare soil at the 21st DAP of maize. Mulching protects the soil from direct sunlight, which reduces water loss by evaporation. These results are similar to results from previous studies (Bougoum, 2012; Kohio, 2015; Doumbia, 2016). However, by the 35th DAP, mulching did not have a significant effect on soil moisture. We noticed a progressive loss of mulch cover due to its decomposition. The straw deteriorated throughout the growing season and its impact on soil moisture diminished.

Concerning the effect of legumes on soil moisture, the results revealed that legumes tended to increase soil moisture compared to soil without cover crops at the 49th DAP of maize. Legumes as cover crops protect the soil from direct sunlight, thereby reducing evaporation from the soil surface. Balboné (2013) found that they increased soil moisture levels when legumes were combined as cover crops. In addition, Coulibaly (2012) reported that biomass production of legumes protects the soil, thereby reducing evaporation from the soil surface. Salez (1988) also pointed out that legume covers reduce the risk of erosion and improve soil moisture. Our results indicate that the effect of legumes varies with the crop species, likely by the fraction of soil cover provided by the legumes. The results confirm those by Balboné (2013), who reported that the effect of cover crops on soil moisture depended on the percent of soil covered and the stage of crop development. In our work, the impact of legumes on soil moisture status was significant at 56 DAP. During this period, cowpea and groundnut reached their maximum surface coverage, which was 99.92% and 89.91%, respectively.

Mulching effects on soil moisture was more pronounced when combined with cover crops such as legumes. Legumes increase the amount of biomass covering the soil. Our results agree with those of Bougoum (2012). Similarly, Doumbia (2016) highlighted that soil moisture content increased with the amount of biomass used.

b) Effects of mulching and legumes on weed growth

The evolution of the weed growth rate differs from one treatment to another. A non-significant difference was detected among treatments regarding the effect of mulching on the rate of grassing. But the rate was higher on the straw plots than on the bare soil. This could be explained by a lack of straw covering the soil, which favored weed development due to moisture. Fredon (2012) indicated that in weed control with mulch, the thickness of the mulch is essential and must be adapted to the materials used. In addition to this component, localized irrigation reduces the amount of weed control by reducing the amount of water available for weeds. Since the moisture content was improved on straw soils, this encouraged weed development. Results overall showed that legumes reduced weed development at 56th DAP of maize. These results could be explained by the ground cover of legumes smothering the weeds. In addition to this aspect, the high biomass production of legumes limits the germination and development of weeds. These results are consistent with those by Espoir et al. (2013), who indicated that when soybean (*Glycine max*) was used as a cover crop, it reduced weed development. Hien (2004) found that the effect of cowpea on weeds was most pronounced at 50th DAP maize. Dao (2014) confirmed these results and reported that the rate of weed growth was low in the maize-cowpea association compared to a pure maize crop. However, we found that weed cover was higher in legume crops than in pure crops from the beginning of production. Mulching using legumes depends on their stage of development (Balboné, 2013).

Similarly, Pamba et al. (2018) had shown that the installation of Mucuna (*Mucuna pruriens* L.) limited the development of weeds such as *Cynodon dactylon*, *Digitaria* sp., and *Imperata cylindrica*. These authors attributed the effect of mucuna to its shading, which was detrimental to weed development. By the 44th DAP, legumes had no significant effect on weed development. The soil moisture content increased, which would enhance weed development. Indeed, Pama et al. (2018) showed that weed control by association is essential in areas with low rainfall.

When combining mulch with legumes, it generally reduced the weed cover at 56th DAP for maize. Legumes increased the amount of biomass available on the soil surface, making it possible to cover the soil well. These results align with Bybee et al. (2018), who showed that crop association could reduce the amount of grass on land plots. Lawane et al. (2010) reported similar results by combining cowpea with cereals to control Striga (*Striga hermontica*).

c) Effects of mulching and legumes on maize growth

The most significant growth was under mulch. Mulching improves soil moisture, mineralization and increases the water available to the plants. Minengu et al. (2015) found similar results for maize plant growth on different cropping systems. Thus, for these authors, soil cover with *Sytholantes guineensis* associated with maize improves the cereal's growth in height and diameter. In contrast, Kouelo et al. (2017) found that mulching had no significant effect on maize crown diameter. According to Azontondé (1993), legumes protect soil and increase earthworm activity, improving soil structure. Improved soil structure allows good rooting and promotes soil colonization by the surface roots of maize plants. In intercropping system, maize makes better use of nitrogen fertilization (Mvondo, 1986). When organic manure is applied, cover crops improve the

nitrogen status of the soil (Balboné, 2013). Atmospheric nitrogen fixation also improves the nitrogen status of the soil (Barikissou, 2012). The improved growth of maize plants in combined legume and mulch treatments is partially explained by the recycling of leached nutrients (Espoir et al., 2013).

Maize grew slowly on plots without mulch because of the rapid drying and moisture loss from unmulched plots, which increases soil strength and slows down the plant root development and slowing mineralization. The unmulched treatments had the lowest growth in plant diameter and height because of the reduced capacity of bare, legume-free soil to promote plant development. This reflects the importance of legume and straw cover.

Moreover, for the diameter at the collar, the difference in mulch combined with legumes was more pronounced from the 30th DAP onwards due to mulch deterioration and nutrient mineralization, leading to improved soil structure, resulting in better water infiltration. However, there was no detectable difference among treatments combining legumes with mulch and the mulch control alone. The nitrogen status of the soil improved plant growth. The application of urea on the 30th DAP, improved the available nitrogen on plots without legumes. After this stage, there was no significant difference between treatments combining legumes with mulching and mulching alone. Overall, all maize plants showed good vegetative development. The drip irrigation system applied sufficient water, as explained by Millogo et al. (2021). Devroc et al. (1982) reported that excess water leads to reduced growth and delayed development of maize plants regardless of the stage at which it occurs.

d) Effects of mulching and legumes on corn yield components

The grain yields were below the variety's genetic potential, estimated at 5.1 t/ha (Sanou, 2009). This low level of performance could be attributed to external factors. Because the experiment was not conducted in a controlled environment, it is subject to climatic conditions that influence maize productivity. Some authors, especially Durburcq et al. (1983), have found a correlation between air temperature and female-flower initiation. This period corresponds to the ear placement and determines the potential for grain production. The high trend in the average number of grains per ear with mulch compared to bare soil would be due to the decomposition of the straw, which enriches the soil and improves its structure. Mulching creates favorable conditions for maize development by improving soil moisture.

However, mulching and legumes did not have a significant effect on grain yield. This could be explained by the fact that there is no water stress in drip irrigation, and secondly, the effect of legumes on soil fertility is long-term. Our results vary from Kouelo et al. (2017), who found that maize grain yield increased from 1,020.5 kg/ha without cover to 2,138.17 kg/ha with cover. These results are also contrary to Roose (2015), who reported that reducing evaporation from the soil surface through straw mulch led to increased crop yields. Our work was under a drip irrigation system. Like Roose (2015), Masvaya et al. (2017) found that mulching combined with organic fertilization increased yield after two years of production. These authors pointed out that straw mineralization increases the amount of nitrogen available in the soil.

Mulching tends to increase straw yield. This work showed an increase in soil moisture and an improvement in soil carbon content due to straw mineralization. These results are in line with those by Bougoum (2012), whereby the effect of mulching was more pronounced in monoculture than in intercropping. Results when including legumes were better than the control because of the improved nitrogen status of the soil from legumes. Legumes also cover the soil cover and increase soil moisture. Our findings are consistent with Salez (1988), who found that more efficient legume resources naturally lead to higher yields.

The results are also in line with Lawane et al. (2010), who pointed out that legumes associated with cereals such as sorghum and millet gave better yields than pure crops. Similar results were reported by Azontondé (1993), stating that the maize-mucuna association increased maize yield. According to Azontondé (1993), the yield increases from 0.2 t/ha in pure culture to 2.8 t/ha in associated culture. Similarly, Pama et al (2018) found that mucuna cover improved maize yields. Mucuna limited the development of weeds, which reduced the competition between maize and weeds. Our results are consistent with Coulibalily et al. (2017a, 2017b), who reported that the crop association increased maize grain yield and that this increase was continuous.

The high associated crop yields are explained by the planting date of the legume, which minimized competition during early growth. According to Fayaud (2012), early growth determines the effectiveness of crop association. Our results agree with Bougoum (2012) that mulching combined with crop association contributed to an increase in sorghum yield of 33 to 72%. Gbakatchetche et al. (2010) also reported that mulching the soil with pigeon pea (*Cajanus cajan* L.) residues increases maize yield.

V. Conclusion

A 3 t/ha rice straw mulch conserved soil moisture in an ASMC drip irrigation system. Mulching improved maize plant growth and the number of grains per ear. However, inadequate mulching favored weed growth the soil was not completely covered. Legumes

did not significantly affect maize growth but had a significant positive effect on soil moisture. The effect of legumes on soil moisture depended upon the legume species used. Peanut and mung bean was more effective than cowpea. Like mulching, legumes tend to promote weed growth at the beginning of production, but as the crops develop, they reduce the rate of weed growth. The combination of cropping and mulching thus reduces grass cover and improves soil moisture during the dry season. Simply mulching or mulching in combination with legumes tends to improve maize growth parameters. Thus, legumes in combination with mulching partially improve the growth parameters of maize.

Mulching alone or in association with legumes did not significantly improve maize yield under drip irrigation. Additionally, some legumes had more noticeable effects with straw. Legumes combined with mulch did not increase maize yield in the dry season. Due to the high yield of maize which could reach 3 to 4 t/ha compared to on-farm yields, maize production could be recommended under a drip irrigation system in Burkina Faso, especially for seed production in case of natural disaster. This work can facilitate interaction between producers and researchers searching for new technologies for changing agriculture. This technology would reduce the operational costs of weed control. In the context of food insecurity due to the scarcity of rainfall linked to climate change, these results show how it would be possible to diversify production during the dry season in a sustainable manner.

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Performance of Broiler Birds Managed on Recycled Litter Treated with Graded Levels of Aluminium Sulphate (Alum)

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Abstract- The study was carried out at the poultry unit of the Department of Animal Science teaching and research farm, Ahmadu Bello University, Zaria to determine the evaluate Performance of Broiler Birds Managed on Recycled Litter Treated with Graded Levels of Aluminium Sulphate (Alum)Two hundred and forty (240) day old Marshall Strain broiler chicks of mixed sexes were used for the study. The birds were fed a common diet during this period and were subsequently weighed and randomly assigned to four treatment groups. The treatments were replicated three times with 20 birds per pen. They were housed under a deep litter system with 15kg recycled litter per pen in a completely randomised design. Aluminium sulphate (alum) was applied to the wood shavings by mixing it with alum thoroughly using hands covered with hand gloves. The rates of alum application was as follows: T1 control (normal with no alum), T2 (5% alum), T3 (10% alum) and T4 (15%).

Keywords: *broiler, performance, carcass, recycled litter.*

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Keywords: *broiler, performance, carcass, recycled litter.*

I. Introduction

Poultry are generally accepted as the fastest way of increasing animal protein consumption in the developing countries of the world (Ogundipe, 1999). This increasing rate of production is raising alarm on the effect of pollution that arises from the land in which this poultry waste is deposited.

Aluminium Sulphate (Alum) has been described as one of the best chemicals used in litter amendment to reduce pathogen levels in litter (improving bird health and food safety), reduce ammonia levels in the poultry houses, reduce phosphorus run off and improve productivity. alum is normally applied at a rate of 5 to 10 percent by weight of the litter (Moore *et al*., 2000). This study was designed to evaluate the effect of alum treated bedding material and poultry litter on litter microbial load and chemical characteristics and its effect on the performance of broilers.

II. Materials and Methods

a) Experimental site and Location

The study was carried out at the poultry unit of the Department of Animal Science teaching and research farm, Ahmadu Bello University, Zaria. The pen is located in northern guinea savannah zone of Nigeria, latitude 11^0 09' 76'' N and longitude 7^0 38' 20'' E at an altitude of 610 mm above sea level. The climate is relatively dry with a mean annual rainfall of 700-1400mm, occurring between the months of April and September (Ovimaps, 2015).

b) Experimental Diets and Material

Broiler starter and finisher diets were formulated to meet the nutrient requirement of broilers (NRC, 1994) and used in feeding the experimental birds throughout the period of the study in both experiment one and two. The experimental diets are shown in Table 1. The alum used was obtained from the Sabon-garimarket in Zaria, Kaduna State.

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Table 1: Ingredients Composition and Calculated Analysis of the experimental Diets

Ingredients	Composition (%)	
	Starter (0 – 4 weeks)	Finisher (5 – 8 weeks)
Maize	51.90	54.50
Groundnut cake	16.00	22.20
Soya bean cake	25.00	15.00
Palm oil	2.00	3.40
Lime stone	1.00	0.90
Bone meal	3.00	2.80
Common Salt	0.30	0.30
Premix*	0.25	0.30
Lysine	0.25	0.30
Methionine	0.30	0.25
Total	100.00	100.00
Calculated analysis		
Crude protein (%)	23.20	21.80
Metabolisable energy (kcal/kg)	2929	3037
Ether extract (%)	6.57	7.74
Crude fibre (%)	4.18	3.78
Calcium (%)	1.23	1.13
Available Phosphorus (%)	0.52	0.49
Lysine (%)	1.13	1.19
Methionine (%)	0.96	0.86
Feed cost (₦/kg)	91.80	88.00

**Composition of premix supplies the following per kg of feed: Vit. A = 12000IU, Vit. E = 15000IU, Vit. D_3 = 2500IU, Vit. C = 30,000mg, Folic acid = 100mg, Nicotine acid = 5000mg, Panthotenic acid = 15000mg, Fe = 1750mg, I = 40,000mg, Zn = 50,000mg, Mn = 100mg, CU = 1500mg, Cu = 200mg, Si = 100mg, Biotin = 600mg, Metabolisable energy calculated according to formulae of Peuzenga (1985). M.E = (37 x %CP) + (81 x %EE) + (35.5 x %NFE).*

c) *Experimental Animals and their management*

Two hundred and forty (240) day old MarshallStrain broiler chicks of mixed sexes were used for the study. The birds were randomly allocated to four treatment groups on arrival in a completely randomised design. The birds were fed a common diet during the period of the study (56 days). The treatments were replicated three times with 20 birds per pen. They were housed under a deep litter system with 40kg poultry litter per pen. Aluminium sulphate (alum) was applied to the poultry litter by mixing it with alum thoroughly using hands covered with hand gloves. The rates of alum application was as follows: T1 control (normal poultry litter with no alum), T2 (5% alum by kg weight treatment of litter from used 5% previously treated wood shaving), T3 (10% alum by kg weight treatment of litter from used 10% previously treated wood shaving) and T4 (15% alum by kg weight treatment of litter from used 15% previously treated wood shaving). Feed and water was supplied *ad libitum* throughout the 56 days study period and routine vaccination schedule was administered.

d) *Data collection and Analyses*

i. *Growth Parameters*

Feed intake, weight gain and feed conversion ratio were determined weekly. Feed intake was calculated by the difference between supplied feed and feed left in each pen. Weight gain was determined as the difference between the weight of the bird in the week under consideration and the previous week. Feed conversion ratio was calculated as the ratio of feed intake and weight gain within each week for each pen. Mortality was recorded as they occurred and body weight was recorded. Mortality percentage was calculated by dividing the number of birds that died within a period by the initial number of birds placed and multiplying by 100.

ii. *Carcass evaluation*

At the termination of the experiment (day 56), two birds from each pen having representative weights for the group (6 birds per Treatment) were selected. The selected birds were bled, dressed and eviscerated. Prime cuts and organs were separated and weighed individually and were expressed as percentages of carcass and live weight respectively.

iii. *Chemical analysis of litter*

The litter samples were analyzed for pH, ammonium ion (NH_4^+) concentration, soluble reactive phosphorus and total nitrogen at the Department of Agronomy, Ahmadu Bello University, Zaria while samples for total VFA were analysed at the chemical laboratory of National Animal Production Research Institute, Zaria, Kaduna State. A 20-g subsample of the litter sample was extracted with 200 ml of deionized water for 2 hours on a mechanical shaker, then centrifuged at 3,687 × *g* for 15 minutes (DeLaune*et al*., 2004). Aliquots were taken for pH, total nitrogen, NH_4^+,

soluble reactive phosphorus (SRP), and total VFA. Unfiltered samples were used for pH using a pH meter and were analyzed immediately. Samples for total nitrogen and ammonium ions were filtered through a 0.45-µm membrane filter and were determined usingKjeldahl method with Kjeldahlapparatus as described by A. O. A. C. (1990). Samples to be tested for soluble reactive phosphorus were filtered through a 0.45-µm membrane filter, acidified to a pH of 2.0 with HCl and frozen until when required for analyses (Moore *et al*., 1995). Soluble reactive phosphorus was determined using the Bray1 method with an auto-analyzer (Spec 20D) according to APHA (1992). Samples for total VFA were not filtered but frozen until when required for analyses Kim (2003). Total VFA was analyzed using steam distillation technique with steam distillation apparatus as described by Chakrabarty(2003).

iv. *Statistical analyses*

All the data collected from the experiment were subjected to analysis of variance (ANOVA) using the general linear model of statistical analysis system (SAS, 2001) software package and the mean separation was done using Duncan multiple range test.

III. Results

a) Performance of Broiler Chickens Raised on Alum Treated and Untreated Poultry Litter

The performance of broiler chickens raised on alum treated and untreated poultry litter is shown in Table 2. The result showed no significant ($P>0.05$) differences among treatment groups in the daily weight gain, daily feed intake and daily water intake. However, there were significant ($P<0.05$) differences in final weight, total weight gain, feed conversion ratio, cost/kg gain and mortality across the treatments. The result showed higher final weight in alum treated litter groups (5%, 10% and 15% alum treated litter) compared to the control (0% alum treated litter), with 10% alum treated litter having the highest final weight of 2.41kg and 0% alum treated litter having the least final weight of 1.96kg. Total weight gain was highest in 10% alum treated litter with 2.36kg and least in 0% alum treated litter with 1.91kg. FCR was higher in 0% alum treated litter with 2.43 and least in 10% alum treated litter with 2.18. Cost/kg gain was highest in 0% alum treated litter with ₦216.05 and least in 5% alum treated litter with ₦194.72. Mortality percentages was highest in 0% alum treated litter with 43.33% and least in 10% alum treated litter with 1.66%.

b) Carcass Characteristics of Broiler Chickens Raised on Alum Treated and Untreated Litter

Table 3 shows the carcass characteristics of broiler chickens raised on alum treated and untreated litter. There were significant ($P<0.05$) differences in live weight, dressed weight, carcass weight, dressing percentage, breast, wings, back, thigh, drum stick and the weight of spleen, heart, liver, lungs and kidney across the treatments. The live weight was significantly higher in 5% and 10% alum treated litter with both having 2400.00g each, followed by 15% alum treated litter with 2270.00g and the least live weight was observed in 0% alum treated litter with 1970.00g. dressing weight was also significantly higher in 5% and 10% alum treated litter with 2320.00g and 2270.00g respectively, followed by 15% alum treated litter with 2080.00g and the least dressing weight was observed in 0% alum treated litter with 1720.00g. Carcass weight followed the same trend as live weight and dressed weight, the carcass weight was significantly higher in 5% and 10% alum treated litter having 1740.00g and 1750.00grespectively, followed by 15% alum treated litter with 1530.00g and the least carcass weight was obtained in 0% alum treated litter with 1310.00g. The dressing percentage was significantly higher in the alum treated litter groups (5%, 10% and 15% alum treated litter) compared to the control group (0% alum treated litter), with the highest dressing percentage in 5% alum treated litter with 96.53% and least in the control group with 87.32%. Percent breast, thigh and drum stick were significantly higher in the alum treated litter groups (5%, 10% and 15% alum treated litter) compared to the control (0% alum treated litter) while percent wings and back are significantly higher in the control (0% alum treated litter) compared to the alum treated litter groups (5%, 10% and 15% alum treated litter). The percent weight of spleen, heart, liver, lungs and kidney were significantly higher in the control (0% alum treated litter) compared to all the alum treated litter groups (5%, 10% and 15% alum treated litter).

Table 2: Effect of Alum Treated and Untreated Litter on Broiler Chickens Performance

Parameter	Treatments				SEM
	Alum Inclusion (%)				
	T1	T2	T3	T4	
Final Weight(g)	1961.00^{c}	2403.00^{a}	2413.00^{a}	2295.00^{b}	11.21
Daily Feed Intake (g)	86.00	95.00	95.00	91.00	4.65
Daily Water Intake (ml)	276.00	264.00	244.00	239.00	11.97
Daily Weight Gain (g)	35.00	39.00	38.00	34.00	2.88
Total Weight Gain (g)	1911.00^{c}	2353.00^{a}	2363.00^{a}	2245.00^{b}	9.43
FCR	2.43^{a}	2.19^{ab}	2.18^{b}	2.35^{ab}	0.07
Cost/kg Gain (₦)	216.05^{a}	194.70^{b}	195.50^{b}	196.00^{b}	3.51
Mortality (%)	43.33^{a}	3.33^{b}	1.67^{b}	5.00^{b}	1.08

^{abc} *= Means on the same row with different superscripts are significantly (P<0.05) different.FCR = Feed conversion ratio. SEM = Standard error of mean.*

Table 3: Effect of Alum Treated and Untreated Litter on Carcass Characteristics of Broiler Chicken

Parameter	Treatments				SEM
	Alum Inclusion (%)				
	0	5	10	15	
Live weight (g)	1970.00^{c}	2400.00^{a}	2400.00^{a}	2270.00^{b}	25.40
Dressed Weight (g)	1720.00^{c}	2320.00^{a}	2270.00^{a}	2080.00^{b}	18.60
Carcass Weight (g)	1320.00^{c}	1740.00^{a}	1750.00^{a}	1530.00^{b}	14.50
Dressing Percentage (%)	87.32^{c}	96.53^{a}	94.44^{ab}	91.93^{b}	1.05
Prime cuts expressed as percent of carcass weight					
Breast (%)	22.56^{b}	26.60^{a}	26.66^{a}	26.40^{a}	0.96
Wings (%)	10.66^{a}	9.73^{b}	9.67^{b}	10.66^{a}	0.25
Back (%)	20.43^{a}	16.75^{b}	16.86^{b}	16.66^{b}	1.08
Thigh (%)	14.40^{b}	16.83^{a}	16.66^{a}	16.46^{a}	0.34
Drum Stick (%)	12.70^{c}	15.70^{a}	15.56^{a}	15.16^{b}	0.29
Organs expressed as percent of live weight					
Spleen (%)	0.26^{a}	0.16^{b}	0.16^{b}	0.14^{b}	0.08
Heart (%)	0.82^{a}	0.46^{b}	0.46^{b}	0.46^{b}	0.07
Liver (%)	3.81^{a}	2.26^{c}	2.27^{c}	2.87^{b}	0.02
Lungs (%)	0.99	0.98	0.98	0.98	0.04
Kidney (%)	1.17^{a}	0.57^{d}	0.57^{c}	0.61^{b}	0.04

^{abc} *= Means on the same row with different superscripts are significantly (P<0.05) different.SEM = Standard error of mean.*

c) Chemical analysis of recycled litter treated with graded levels of Alum

The fortnightly(week 2, week 4, week 6 and week 8) result of the effect of alum treated poultry litter on litter pH is presented in Figure 1. The result shows significantly (P<0.05) Lower pH values in all the alum treated litters groups (5%, 10% and 15% alum treated litter) compared to the control group (0% alum treated litter) for weeks 2, 4, 6 and 8. The pH levels decreases with increasing levels of Alum in week 4 and 6 (P<0.05). The result of total nitrogen levels of alum treated and untreated litter at two week intervals during the research period is presented in Figure 2. The result shows significantly (P<0.05) higher nitrogen content in all the alum treated litters (5%, 10% and 15% alum treated litter) compared to the control (0% alum treated litter) for 2, 4, 6 and 8.

The fortnightly soluble reactive phosphorus levels of alum treated and untreated litter is presented in Figure 3. The result shows significantly (P<0.05) lower soluble reactive phosphorus level in all the alum treated litter groups (5%, 10% and 15% alum treated litter) compared to the control group (0% alum treated litter). Figure 4 shows the fortnightly total volatile fatty acid levels of alum treated and untreated litter. The result shows significantly (P<0.05) lower total volatile fatty acid levels in all alum treated litter groups (5%, 10% and 15% alum treated litter) compared to the control(0% alum treated litter).The fortnightly ammonium ion (NH_4^+) concentrations of alum treated and untreated litter is presented in Figure 5. The result shows significantly (P<0.05) higher ammonium ion concentration in the alum treated litter groups (5%, 10% and 15% alum treated litter) compared to the control (0% alum treated litter).

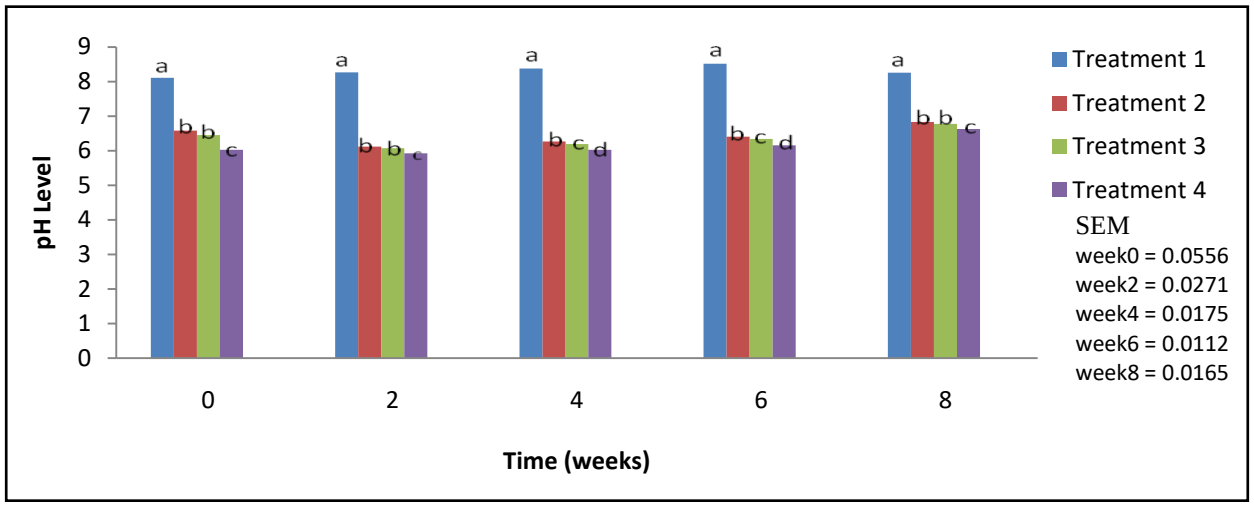

Figure 1: pH Levels of Alum Treated and Untreated Litter

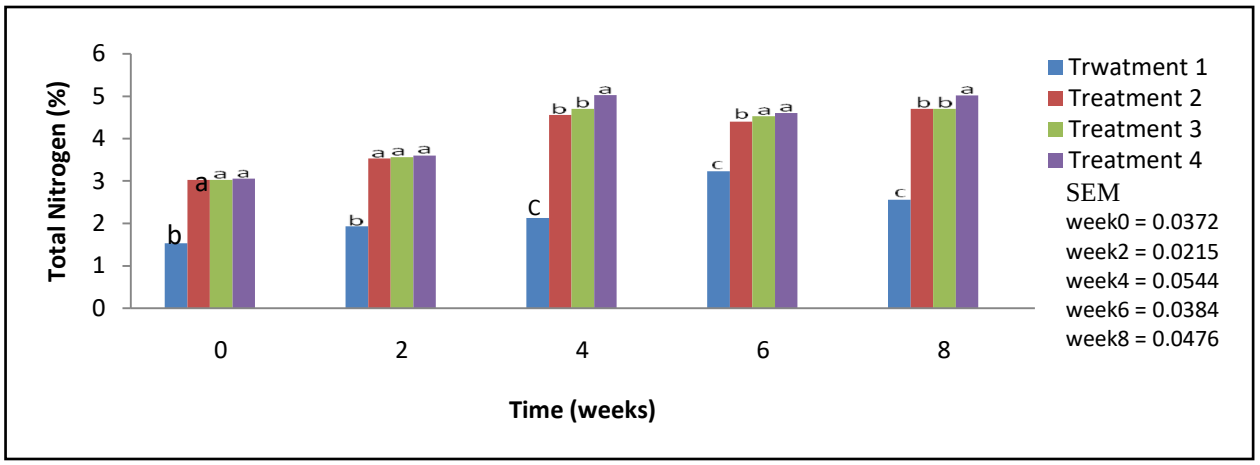

Figure 2: Total Nitrogen Levels of Alum Treated and Untreated Litter

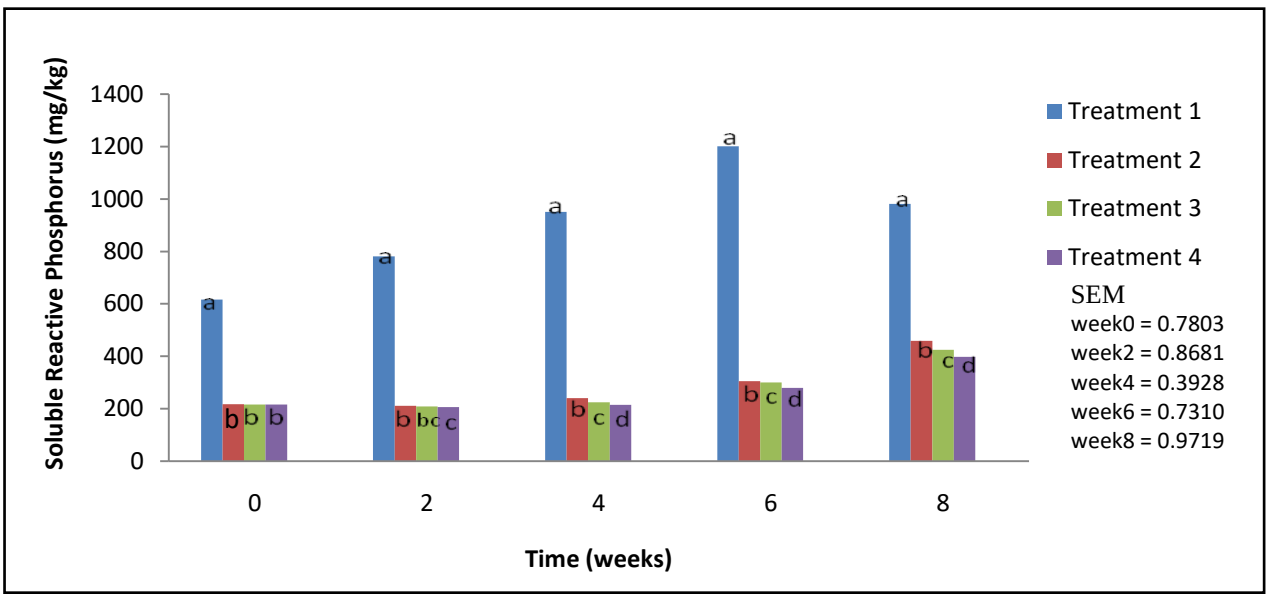

Figure 3: Soluble Reactive Phosphorus Levels of Alum Treated and Untreated Litter

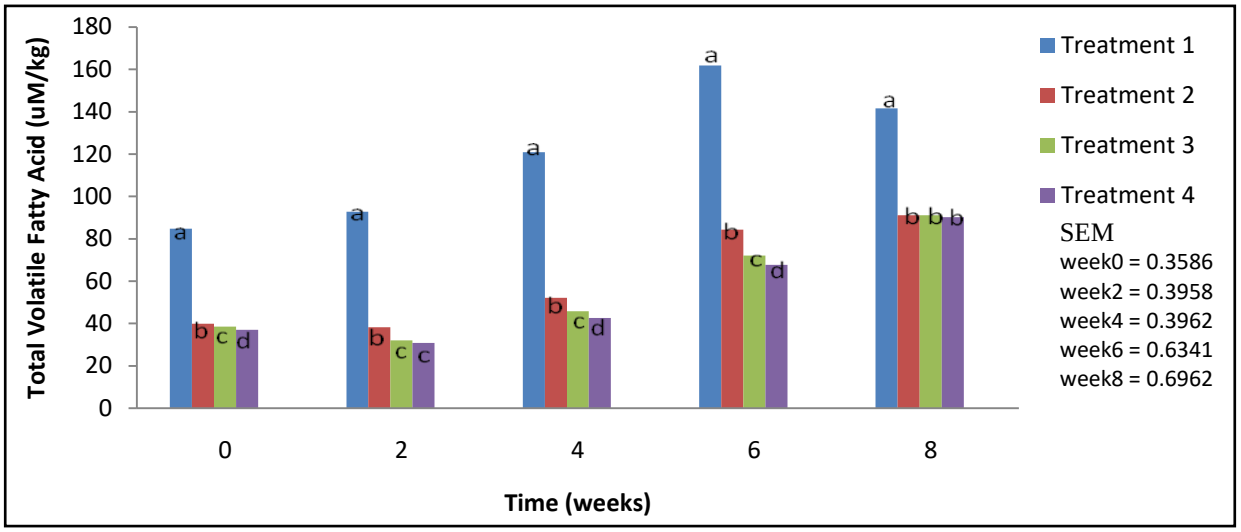

Figure 4: Total Volatile Fatty Acid Levels of Alum Treated and Untreated Litter

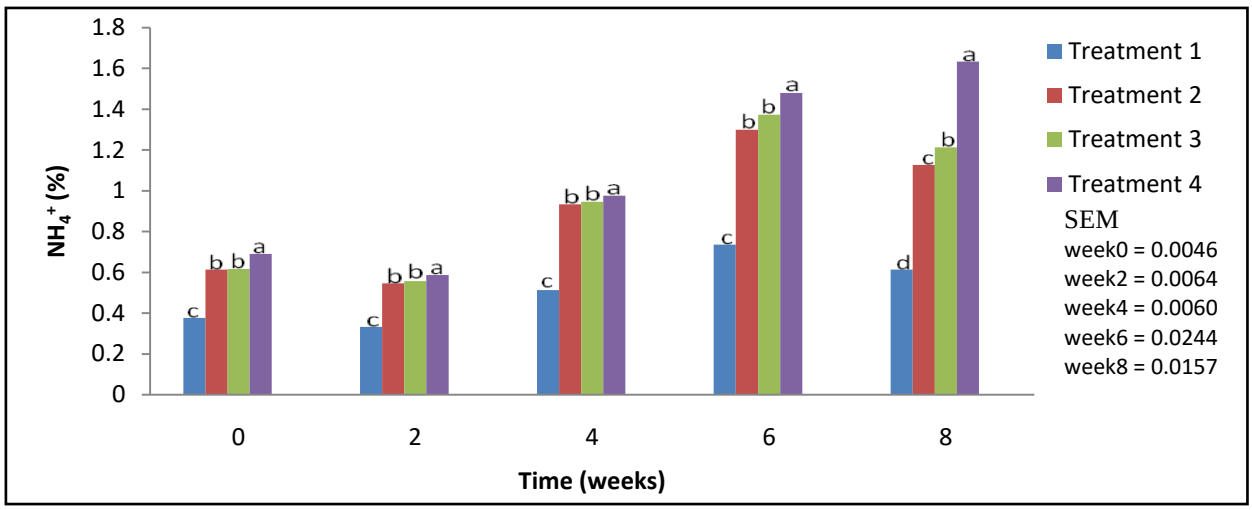

Figure 5: Ammonium ion (NH_4^+) Concentrations of alum Treated and Untreated Litter

IV. Discussion

a) Performance of Broiler Chickens Raised on Alum Treated and Untreated Litter

The improved final weight, feed intake, FCR and cost/kg gain in the alum treated litter groups (5%, 10% and 15% alum treated litter) is in agreement with that obtained by Moore *et al*. (2000), who reported that alum treatment to poultry litter resulted in increased weight gains and improved feed conversion. This significant difference observed between the alum treated litter groups (5%, 10% and 15% alum treated litter) and the untreated litter (0% alum treated litter) can be attributed to the haematological parameters of the birds in this groups, hence indicating immune challenge condition of birds in the control group. The significantly higher final weight and weight gain observed in 5% and 10% alum treated litter compared to 15% alum treated litter may be due to the high alum concentration in the litter in 15% alum treated litter, which is similar to the result obtained by Choi and Moore (2008), who reported significantly higher weight gain in lower aluminium chloride compared to the high aluminium chloride treatment. Birds in 15% alum treated litter were observed to be limping during the study period. In general, alum treatment to broiler litter improves feed conversion, increased weight gains and resulted in fewer mortalities (Forbes and Robert, 2012).

b) Carcass Characteristics of Broiler Chickens Raised on Alum Treated and Untreated Litter

The significantly higher live weight, dressed weight, carcass weight, dressing percentage and percent breast, thigh and drum stick in the alum treated litter groups (5%, 10% and 15% alum treated litter) compared to the untreated litter group (0% alum treated litter) and the significantly higher percent wings and back can be attributed to the health status of the birds as shown from the haematological parameters of the birds which agree with the result of Chinrasri and

Aengwanich (2007) indicating that the birds in the control (0% alum treated litter)group may behaving immune challenges, while the significantly higher Spleen, heart, liver and kidney observed in the untreated litter group compared to the alum treated litter groups can be also attributed to the disease condition of the birds as reported by Abeke*et al.* (2008), who reported that hypertrophy of organs may occur as a result of the body's attempt to increase protein availability or in the process of detoxifying toxic substances taking in or secreted by pathogens in the body.

c) Chemical analysis of recycled litter treated with graded levels of Alum

The significant decrease in pH levels of alum treated and untreated litter showed a significant decrease in litter pH between alum treated litter groups (5%, 10% and 15% alum treated litter) compared to control (0% alum treated litter), is in agreement with the result obtained by Choi and Moore (2008), who reported pH values to be 8.04 and 7.42 in the control and $AlCl_3$ treated litter respectively. The reduction in pH level observed in the alum treated litter can be attributed to the reaction of alum with H_2PO_4 in the litter resulting in the generation of acidity in the litter as reported by Penn and Zhang (2013). This reduced pH level in the litter agree with the result obtained by Moore *et al*. (1998) and Moore *et al*. (2000), who reported thatalum addition to poultry litter significantly reduces the pH of the litter. The significant increase in the total nitrogen content of the litter in the alum treated litter groups (5%, 10% and 15% alum treated litter) compared to the control (0% alum treated litter) is in agreement with the report by Penn and Zhang (2013) who reported 4.24 % nitrogen in alum treated litter compared to the control untreated litter with 3.97% nitrogen at week 6.This significantly higher nitrogen level observed in the alum treated litter may be due to conversion ability of alum (aluminium sulphate) for nitrogen from gas form to a more stable solid form in the litter i.e. through the conversion of NH_3 gas to $(NH_4)_2SO_4$ by the reaction of sulphate with NH_3 in the litter as reported by Charles (2005). The significant higher nitrogen level in the litter is also similar to the report of Moore *et al*. (1998) and Moore *et al*. (2000) who reported the average total nitrogen contents of alum treated litter to be significantly higher compared to untreated litter. This nitrogen availability, indicate that crop yields could be higher when litter treated with alum is used as manure as reported by Shreve *et al*. (1995) and Moore and Edwards(2005).

The soluble reactive phosphorous levels reduction of the litter for alum treated at week 8 by 53.25%, 56.70% and 59.46% for5%, 10% and 15% alum treated litter respectively compared to the control is similar to that obtained by Shreve *et al*. (1995) who reported that alum treated litter lowered phosphorus concentrations in runoff by 87% and 63% compared with alum untreated litter for the first and second runoff events respectively. The significantly lower soluble reactive phosphorus level observed in the alum treated litter may be due to the impact of alum (aluminium sulphate) on the water solubility of phosphorus in the litter, thereby making the Phosphorus in the litter less water soluble and hence reducing phosphorus runoff on land as reported by Moore *et al*. (1998) and Moore *et al*. (2000). This is also similar to the findings of Shreve *et al.* (1995, 1996) and Dao *et al*. (2001) who reported that Al, Ca, and Fe amendments reduced soluble phosphorus in animal manures. Smith *et al*. (2001) reported that alum and $AlCl_3$ treatments produced reduced soluble reactive phosphorus concentrations in runoff by as much as 84% compared with normal manure and were not statistically different from soluble reactive phosphorus concentrations in runoff from unfertilized control plots. Choi (2004) reported that concentrations of soluble reactive phosphorus were 83% lower for $AlCl_3$ (200 g/kg of rice hulls) treated litter. Moore *et al*. (1998, 1999) explained that one of the reasons alum was chosen for phosphorus control in poultry litter was because alum is stable over a very wide range of pH conditions. The reduction in the total volatile fatty acid concentration by 35.6%, 35.72% and 36.25% in the 5%, 10% and 15% alum treated litter respectively when compared to the 0% alum treated litter group is in line with the report ofChoi and Moore (2008), who reported 51% of total volatile fatty acid reduction with aluminium chloride treatment to poultry litter.

Wilson (2000), Line (2002) and Choi and Moore(2008) hypothesize that it was due to the pH effect of acidifiers, which would inhibit microbial growth and activity in poultry litter. Similar findings have been observed by Varel and Miller (2004) who reported that when eugenol was added to animal manure it reduced VFA production by 70% and 50% in cattle and swine manure, respectively. They suggested that eugenol suppressed microbial activity by lowering manure pH and inhibiting the production of VFA that are considered the predominant odour compounds emitted from livestock wastes. The ammonium ion concentrations of the litters were 23.89%, 23.95%, 25.81 and 32.53% of the total nitrogen content of the litter for 0%, 5%, 10% and 15% alum treated litter respectively. This result is similar to that obtained by Choi and Moore (2008), Sims (1986, 1987) and Chadwick *et al*. (2000) who reported ammonium nitrogen representing 11% to 66% of the total nitrogen contents from control and all liquid $AlCl_3$ treatments. The significantly higher ammonium ion concentration observed in the alum treated litter groups (5%, 10% and 15% alum treated litter) is due to the higher nitrogen content of the litter resulting from reduced NH_3 emission as reported by Moore and Watkins (2012).The content of NH_4^+ and mineralizable organic nitrogen fraction (plant available nitrogen) in manure and litter plays an important role in determining

the value of animal wastes as nitrogen fertilizer (Choi and Moore, 2008).

V. Conclusion

The study conclude that treating recycled poultry litter with alum can increase total nitrogen and ammonium ion concentration of the litter and reduce pH, total volatile fatty acid and soluble reactive phosphorus content of the litter, thereby making the litter to be a better manure for crop production and reduce odour in poultry houses.

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Primate Population Census and Feeding Preference in Bagale Forest Reserve of Adamawa State, Nigeria

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Abstract- This study was carried out to determine the absolute densities and food preference of primate species in Bagale forest reserve of Adamawa State. The King Census model was used for determination of absolute densities while the frequencies of utilization of food materials was used to determine preference ranking.

Result of the study indicate that absolute densities for Patas monkey (*Erythrocebus patas),* Tantalus monkey (*Cerlopitecus tantalus)*and Baboon *(Papio anubis)* were 0.28/km^2, 0.21/km^2 and 0.07/km^2 respectively. Fruits of *Vitex doniana, Anona senegelensis, Ziziphus maurit/ana and Detarium microcapum* were found to be preferred by the primates in the study area.

Keywords: primate, census, in-situ, reserve and preferences.

GJSFR-D Classification: FOR Code: 070199

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Primate Population Census and Feeding Preference in Bagale Forest Reserve of Adamawa State, Nigeria

Boni P. G. [α], Yaduma, Z. B. [σ], Lumbonyi, C. A [ρ] & Modu, M [ω]

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I. Introduction

There are three, known species of Primate in Bagale Forest reserve of Adamawa State. Patas monkey *(Erythmcebus patas),* Tantalus monkey *(Cercopithecus tantalus)* and Baboon *(Papio anubis)*. Although they appear to be relatively abundant, there is no quantitative data available as to their status.

Wild animals census particularly for in-situ conservation areas is very important. Dunn (1993) observed that for effective wildlife management in protected areas, policies must be based upon reliable and appropriate data. Mc Kinnon *et al*(1986), reported that the effective conservation of wild animal resources require the knowledge of what species occur within the conservation area, where and in what numbers as well as what are population trends over time?

Primate census is also very important in that it provides useful information regarding the magnitude of local hunting pressure and the health status of the conservation area, Akosim (1997), reported that the flourish primates populations are usually indicators of general good health of the forest ecosystem. For example, if there is a full complement of species and the population density of each is high, then the hunting pressure can be said to be low and the conservation area to be in good health, on the other hand low population densities and local extinctions of some species are indications of high hunting pressure and the presence of other adverse conditions (Dost and Dandlot, 1990; Dunn 1992).

However, it has been observed that increase human population has taken its toll on forest resources as a result of increase in demand for land for arable farming, logging for timber for construction of houses, road construction and urbanization. (Ijomah and Akosim 2000). This situation has led to serious increase into conservation area such forest and game reserve with the attendant depletion of wildlife resources including primates.

Therefore the primate census of Bagale forest reserve would not only provide information on the status of the primate in the reserve but would also indicate the health status of the habitat. These information will serve as baseline data for the development strategies and for proper management of the habitat.

Furthermore, knowledge of the food items preferred by the primate will also help to determine the overall management strategies that will ensure adequate cover and food for the primate. Primate population and food preference studies have not been carried out in Bagale forest reserve since its establishment, have the need for this study which aimed at determining the absolute density and food preference of the primate species in the study area.

a) Factors that Determine Wildlife Population

Piteka (2002) recorded that ecological factor such as competition affect the population size of animals while predators remove individuals from pray populations and may directly influence both survival and reproduction. The physical factors include temperature, rainfall, wind and relative humidity as observe by (Ijomaj and Akosim 2000).

Seber (1999) listed some of the sociocultural factors affecting wildlife conservation in Nigeria to include the belief that wildlife resources is inexhaustible as well as lack of awareness of the benefit of conservation.

b) Wildlife Population Census

There are many reasons why wildlife population census are conducted. According to Dunn (1993)

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wildlife is increasingly being regarded as renewable resources. Akosim (1997) listed various methods use in wild animal enumeration at various places. These methods already in use include: Total count, the use of quadrat, line transect method, capture, marking and recapture, and indirect method such as fresh dropping and foot print. Each of these methods has it merits and demerits. The method use depends on the objectives of the study, the peculiarity of the habitat, the animal to be counted and the facilities available.

c) Forage Preference

Halls (2005) stated that preferred plant species are those chosen and eaten by the animals more frequently than other. Ijomah and Akosim (2000) associated forage preference with palatability. They reported that palatability is that quality in forage plants that makes it preferred when a choice between plants is available.

Selection may also be influenced by availability in situations where there are few species and each occur in limited quantity the only alternative is to feed on the available species (Akosim 1997).

II. Methodology

a) Study Area

Bagale Forest Reserve is located within Girei Local Government Area of Adamawa State, Nigeria. It extends between latitude 9° 11° N and 9° N and longitude 12° 20° E 12° 30° E with a total area of (111.04km^2). The reserve is bounded to the North by Song, to the East and South by Fufore and to the West by Yola North Local Government Areas.

The area is dominant by Bima sandstone, it consists of fine sand, clayish sand silt ironstone and alluvium deposits, which consist of both clay and salty clay. The reserve experience two distant seasons, the dry season, which last from November to March and the raining which last from April to October. The Minimum rainfall is 0.4mm while maximum rainfall is 475mm with a total rainfall of 1030mm per annum (MAU 2020).

The vegetation is savanna woodland. It also has the characteristic of open biotype. Trees that are common include *Vitex doniana,Tamarindus indica, Veteileria Paradoxa, Parkia biglobosa, Burkea africana, Combretun, hypopilum, Khaya senegalensis* etc, while grass species that are commonly found include: *Andropogon gayanus, Bidens pilosa, Panicum, maximum, Seteria, tarbata, Pennisetum, pediceitatum, Ipomea trileba* and so on (Akosim *et al,*2020). The Fauna resources in the study area consist of Lion (Panthera Leo), Red Patas monkey *(Erythrocebus patas),* Baboon *(Papio anubis),* Tantalus monkey *(Cerlopithecus tantalus),* Rock Python *(Python regins),* Ground squirrel *(Xerus erythropus) etc.*

b) Study Design

A reconnaissance survey prior to detailed study was carried out. This was 'to enable the researcher to assess the species of primate in the reserve, type of food available and their distribution.

Three transect 1km apart were cut at random based on Ogunjemite (2004) methods. The length of the transect vary from 8km to 9km according to the nature of the area. The three transects were cut following a sighting compass on a predetermined bearing. The width of the transect was 2.5m while the length were accurately measured using a 50m tape.

III. Data Collection Techniques

a) Primate Census Study

Each transect was walked once in a day for 10 days. The census took place between 6:00am and l: 00pm. The census commenced at approximately the same time each day. They were three observers. Observers moved slowly and quickly at the rate of l-l.5km/hour stopping occasionally to listen and watch for animal. When the primate were encountered, the species group, size and the group spread swere noted and the sighting distance measured.

b) Food Preference Study

The direct observation method as described by Tomlison (2004), was used with modifications. Hence instead of using the feeding - minute or Bite count, in relation to percentage available to determine food preference, the frequency of sighting or occurrence of forage species in the animal's diet was used as index or preference and consumption. The technique involved the use of binoculars to observe the specific site where feeding took place, followed immediately by onsite inspection of the utilized plants for the purpose of identification. Records of the utilized food items were made from which the frequency of occurrence of each forage species in the animals diet was determined. The preference ranking was carried out according to the order of magnitude of the frequency, thus providing a preference ranking for each species (Tomlison, 2004)

IV. Data Analysis

Estimate of absolute densities of primate encountered was carried out using the kings census model as follows:

$$D = {}^{n}/_{2LF}$$

Where D=the absolute density,
n=Total number of individual of a species sighted
L= Average sighting distance

Frequency distribution was used in analyzing data on food preference study.

V. Result and Discusion

The result of the study are presented in Tables 1,2,3 4 and 5. Table 1, shows the result of absolute densities of primate in the study area. A total of three species of primate were censused in the reserve. The result indicated that the absolute densities for primate were baboon (0.17/km^2), Patas monkey (0.28/km^2) and Tantalus monkey (0.021/km^2) the result shows that Patas monkey had the highest occurrence per square kilometer while Baboon has the least. The result of absolute" population densities of the primate species, are indicative of their status in the forest reserve. This observation agreed with Dost and Dandelot (1990) report of primates characteristic of northern guinea Savanna. However, when the result is compared with what was obtained by Gawaisa (1997) for Baboon (2.62/km^2), Tantalus (1.36/km^2) and Patas (0.34km^2) in Gashaka Gumti National Park, the population of primates in Bagale for estreserve may be said to be low. The primate species population result from this is an indication of the fact that one or more of the factors that negatively affects wildlife population are in operation in the reserve. This situation must have resulted from illegal removal of wood resources from the reserve for fuel wood and building as well as extension of agricultural land into the reserve resulting in total clearing of wood plants upon which the primates depend for both food and cover. The record of daily sighting are presented in Table 2 to 4.

In transect 1 (Table 2) out of a total of 566 sightings, S41 (96%) were in "group" 18 (3%) were "solitary" and 7 (1%) uncertain, while in transect 2(Table 3) out of a total of 356 sightings 338 (94.9%) were in "group" 18 (5.5%) were solitary and none uncertain. In transect 3 (Table 4) shows that for a total of 387 sightings 371 (95.9%) were in "group" 14 (3%) were "Solitary" and 2 (0.52%) were uncertain.

Result of food preference ranking (Table 5) indicates the food plants (fnut) preferred by primates in the reserve. Baboon mostly feed on the fruits of *Vitex doniana,* followed by *Annona senegalensis* and *Ziziphus mauntiana* Patas monkey preferred the fruits of *Annona senegaless* followed by *Detarium microcapun* while Tantalus monkey mostly fed on the fruits of *Detarium microcapum* and *Prospis africana.* All primates in Bagale forest reserve utilized fruit of *Annona senegalensis as* indicated in the Table.

VI. Conclusion

The results of this study shows that the Bagale Forest reserve contains representative sample of primates found in the Savanna ecosystem. The status of the primates when compared with what obtains in similar ecosystem of the Savanna indicates that the primates' populations in the reserve are low. The low population is not unconnected with high incidence of poaching, and deforestation of the reserve. Result of the food preference study showed that the three primate species selected *Annona Senegalenois as food vitex domiana and Ziziphus mauntiana were preferred by Baboon, patas monkey preferred Detarium microcapum in addition to Anona Senegalensis while Tantalus monkey fed mostly on Detarium microcapum and prosopis africana.*

Table 1: Estimate of primates population in Bagale Forest Reserve

Primate	Absolute densities No/km^2
Baboon *(Papio Anubis)*	0.17
Patas Monkey *(Erythrocebus patas)*	0.28
Tantalus Monkey *(Cercopithecus tantalus)*	0.12

Table 2: Type of sighting of primate species at transect 1 in the study area

Species	Group	Solitary	Uncertain	Total
Baboon	170	10	5	185
Patas Monkey	211	6	0	217
Tantalus Monkey	160	2	2	164
Total	541	18	7	566

Table 3: Sighting of primate species at transect II in the study area

Species	Group	Solitary	Uncertain	Total
Baboon	83	1	0	84
Patas Monkey	165	14	0	170
Tantalus Monkey	90	3	0	93
Total	338	18	0	356

Table 4: Type of Sighting of primate species at transect III in the study area

Species	Group	Solitary	Uncertain	Total
Baboon	131	0	0	131
Patas Monkey	140	12	1	153
Tantalus Monkey	100	2	1	103
Total	371	14	2	387

Table 5: Food preference/Ranking for Primate in the study area

S/N	Primate Species	Species of Plant Utilized	Ranking/Frequency
1.	Baboon	*Vitex doniana*	1
		Annona Senegaiensis	2
		Ziziphus Spina-christi	2
		Ziziphus Mauritiana	3
		Gardenia aecqulla	3
		Combratum spp	4
		Ficus platyphylla	4
2.	Patas Monkey	*Annona Senegaiensis*	1
		Detarium Microcarpum	2
		Vitex doniana	3
		Ziziphus Mauritiana	3
		Vetellaria Paradoxa	3
		Balanite aegyptica	4
		Tamarindus indica	4
		Ficus platyphylla	4
3.	Tantalus Monkey	*Ziziphus mauritiana*	1
		Deterrium microcarpus	2
		Prospis africana	2
		Balamite aegyptica	3
		Ximanania Americana	3
		Annona senegalensis	3
		Vetellaria aradoxa	4
		Parkia biglobosa	4
		Ziziphus spina-christi	4
		Vitex doniana	4

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Combined Effect of Quinoa and Germinated Wheat Flour on Physicochemical, Sensory and Microbiological Stability of Cupcakes

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Abstract- The objective of this study was to evaluate the physicochemical, sensory and microbiological stability of cupcakes during storage after the addition of different proportions of quinoa flour along with germinated wheat flour (GWF). The different levels of quinoa flour (0-15%) and germinated wheat flour (0-15%) were utilized in the cupcakes formulation. The cupcakes containing quinoa flour exhibited greater firmness and water activity than the control cupcake. Hardness and elasticity results revealed that the cupcakes with quinoa flour and GWF were statistically different from those with only quinoa flour and GWF as well as the control cupcake. Moreover, cupcakes with quinoa flour had greater acceptance and preference on the part of consumers. In addition, these cupcakes showed lesser growth of molds after 15 days of storage; this indicated that the aforementioned additive could extend the shelf life of cupcakes. These results showed that the addition of quinoa flour led to cupcakes with better sensory and textural properties and greater stability during storage.

Keywords: *pseudo-cereals; texture; gluten-free; microbiological stability.*

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Combined Effect of Quinoa and Germinated Wheat Flour on Physicochemical, Sensory and Microbiological Stability of Cupcakes

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Abstract- The objective of this study was to evaluate the physicochemical, sensory and microbiological stability of cupcakes during storage after the addition of different proportions of quinoa flour along with germinated wheat flour (GWF). The different levels of quinoa flour (0-15%) and germinated wheat flour (0-15%) were utilized in the cupcakes formulation. The cupcakes containing quinoa flour exhibited greater firmness and water activity than the control cupcake. Hardness and elasticity results revealed that the cupcakes with quinoa flour and GWF were statistically different from those with only quinoa flour and GWF as well as the control cupcake. Moreover, cupcakes with quinoa flour had greater acceptance and preference on the part of consumers. In addition, these cupcakes showed lesser growth of molds after 15 days of storage; this indicated that the aforementioned additive could extend the shelf life of cupcakes. These results showed that the addition of quinoa flour led to cupcakes with better sensory and textural properties and greater stability during storage.

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I. Introduction

Pseudocerealsdo not belong to the Gramineae family and produce seeds which can be milled into flour and applied like as cereal crops. They are known to be gluten-free and suitable for Celiac disorders which these fiber-rich grains with high diversification of gluten-free items are available on the market(Alvarez-Jubete et al., 2010). Quinoa (*Chenopodium Quinoa*) seeds are known as pseudocereal, and due to their high fiber (~15%) and protein (~13%)containing essential amino acids such as lysine, threonine and methionine which are insufficient is some cereals; have found great attention in the world (López-Alarcón et al., 2019; Wu et al., 2017). Quinoa can be incorporated into various products such as bread, cookies, pasta, cakes and chocolates (Acosta-Dominguez et al., 2016; Casas Moreno et al., 2015; Pop et al., 2014; Wang et al., 2015). Due to the high quality of quinoa protein, it can be applied to improve protein from different sources and utilized for Celiac diseases treatment (Abugoch et al., 2008; Alencar et al., 2015). Therefore, FAO has selected it as one of the destination crops to offer food security in the 21st century (Jacobsen, 2003).

The convenient processing and accessibilities of cupcakes in the parties, makes it a suitable choice which can be designated by quinoa flour as a panelist product for celiac disorders (Abdel-Moemin, 2016). However, the quinoa flour products are often poor quality due to quality degradation by shelf life, have lower loaf volume, poor texture and mouth feel due to the lack of gluten elasticity and low nutritional value (Turkut et al., 2016). So, it is required to improve the structural and textural properties of the products from quinoa flour through some physical, chemical and enzymatic modification. Although, some thermal processing have been used to change its physicochemical properties of protein and starches(Acosta-Dominguez et al., 2016; Mirmoghtadaie et al., 2016).It has also been reported that thermal processing make different effects on the protein functionalities and induce gelation of quinoa protein, which has been attributed to the protein characteristics such as molecular attractions, which lead to the irreversible bond formation between aggregates of globular proteins (Ako et al., 2010; Kaspchak et al., 2017). Indeed, baking industries are so interested in comprising new additives to extend shelf life of the products due to its deterioration by presence of molds which has a severe economic loss in the products (Samapundo et al., 2017).

Wheat germination improves the bioavailability of nutrients and offers many health benefits. For instance, folic acid is increased 3 to 4-fold in germinated wheat flour (GWF) depending on the temperature processing of wheat germination (Hefni & Witthöft, 2011). Since the protein content of GWF (about 9%) is more than whole wheat flour, it can be developed in the baking process. Furthermore, GWF has higher oil absorption capacity and water solubility index which can be useful in different baking products such as cupcake(Dhillon et al., 2020). GWF was also evaluated for using in bread making and interesting results were achieved (Park & Morita, 2005). Due to the high nutritional and functional properties of GWF, it is

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interesting to incorporate in various products for value addition such as weaning foods (Gulzar, 2011). Therefore, the effect of GWF along with quinoa flour in cupcakes is investigated here.

Since, to the best of our knowledge there is no research work on the effect of quinoa flourmixed withGWF on the physicochemical, textural properties and microbiological stability of a cupcake, the objective of the current work was to evaluate the effect of quinoa flour addition on the physicochemical, sensory and textural properties of cupcakes and its stability for storing at room temperature in the shelf of the markets.

II. Materials and Methods

a) Materials

Quinoa (*Chenopodium quinoa*) seeds were purchased from a local organic market (OAB, Tehran, Iran). In order to eliminate the raw taste of quinoa, it was roasted at 180°C for 10 min. Germinated wheat flour was prepared according to the method of Hefni & Witthöft with slight modifications (Hefni & Witthöft, 2011). In brief, wheat germination was performed for 48 h in a leavening cupboard. Then, GWF was dried in a conventional oven at 50°C. Both roasted quinoa and germinated wheat samples were then milled and packed in polyethylene hermetic plastic bags and stored at 4°C until the experiments. Cupcake ingredients including sugar, glucose, egg, vanilla, baking powder, edible oil and salt were obtained from local markets.

b) Physicochemical analysis

Physicochemical analysis of quinoa flour and GWF including moisture content (AACC, 44-19), ash (AACC, 08-01), lipid (AACC, 30-20) and protein content (AACC, 46-30) (N×5.96) were evaluated (AACC, 2000). Total crude fiber contents of the flour were assayed using the AOAC method no 991.43 (AACCI., 1995).

Cupcakes with different levels of quinoa flourand GWF were analyzed for pH after baking. In order to measure pH, water and cakes in equal amounts by weight were stirred in a beaker, and slurry was formed. Then, pH value was measured (Jenway, England). Water activity (a_w) was determined by using a water activity meter (Aqualab, 3TE, Decagon, USA). Moisture content was measured gravimetrically based on weight loss by oven drying at 60°C until a constant weight was achieved. The superficial color was analyzed using black box method by using the CIElab parameters L^*, a^* and b^* according to our previous work (Abdollahi Moghaddam et al., 2015). The specific volume of the cupcakes was determined according to the AACC methodology, 55.50.01(AACC, 2000). The cupcakes were weighed using a semi-analytical balance, and the volume was measured by millet seed displacement. The specific volume was calculated from the relation of volume to weight and the results are expressed as cm^3/g.

c) Cupcake formulation

A basic formulation reported by Abdel-Moemin(2016) at different levels of quinoa flour and GWF was used (Table 1). All ingredients were thoroughly mixed for 5 min. Cupcake papers were fitted into each of the 12 wells in the cupcake tray (34×26 cm). The cupcake papers were filled with 60 g of the batter and then baked at 190°C in the Mini Cupcake Maker. Then, they were allowed to cool and packed in polyethylene bags and stored at ambient temperature and dry place prior to the experiments.

d) Textural Profile Analysis (TPA)

Textural properties of cupcakes were determined using the TA-XR2 texture analyzer (Stable Micro System Co. Ltd, Surrey, England), equipped with a 5 kg load cell. A cylindrical probe of 36 mm diameter was attached to the crosshead. The instrument test was as follows: Pre-test speed: 1.5 mms^{-1}, crosshead speed: 1 mms^{-1}, post-test speed 1.5 mms^{-1}, and compression was set to 40%. The cupcakes loaves were sliced to 15 mm thickness and the crusts were removed before analysis. Textural parameters including hardness, elasticity, cohesiveness, resilience and chewiness were measured. Data were analyzed by using Texture Expert Exceed Software supplied with the instrument. All the tests were performed in triplicates, and the average and standard deviation are reported.

e) Sensorial properties

Cupcakes with different levels of quinoa flour were presented separately to 60 consumers. A 5-point hedonic scale, ranging from 1 for 'dislike extremely' to 5 'like extremely' was used to determine their degree of acceptance among the products supplemented with germinated wheat flour at varying levels.

f) Microbial experiments

All the cupcakes were packed in sealed plastic bags and stored at 20°C. They were checked daily for visible mold growth and weekly by culturing in the media (Debonne et al., 2018).

g) Statistical analysis

Data analysis was triplicates. The means and standard deviations were analyzed using ANOVA followed by the Turkey's post-hoc test at the significance level of 5% ($P<0.05$).For the sensory analysis, the data were analyzed via the Friedman test, equivalent to the ANOVA test. All analyses were performed using the Minitab 16 statistical software (MinitabInc., State College, PA, USA).

III. Results and Discussion

a) Physicochemical and appearance properties of cupcakes

Physicochemical properties of quinoa flour and GWF are provided in Table 2.As it can be seen, QF has

high protein content which is more than that of GWF. Similar protein content was also reported for GWF in the literature (Enujiugha et al., 2003). In contrast, QF did not have any gluten and it is a proper product for celiac people. The fat content and crude fibers were 2.30 and 2.24%, respectively, which were in agreement with other scientific findings (Dhillon et al., 2020). The crude fibre is the insoluble residue of the acid hydrolysis followed by an alkaline one. Insoluble structural fibers such as cellulose, hemicellulose, and lignin which are the important part of cell wall are included in fibre fractions (Chaudhary & Vyas, 2014).The mineral content of QF was more than the GWF (1.65%). Similar mineral amount was also found for GWF and reduction of mineral in GWF has been attributed to the loss of the mineral content during soaking (David et al., 2015).

Moisture content (MC) and water activity (a_w) are two factors should be considered during the baking process, as excessive water can cause overexpansion during baking and breakdown of the loaves during storage, compromising the stability of the product (Encina-Zelada et al., 2018). Partial substitution of wheat flour with QF and GWF produced different moisture content and a_w from 15.70 to 25.48% and 0.68 to 0.82, respectively (Table 3). For all the samples, moisture and water activity exhibited reduction during the storage. The highest MC and a_w were obtained in the sample containing 15% GWF. Since there was not statistically significant difference in the MC of the sample with 15% QF with the control ($P<0.05$), it can be recommended to apply the formula for celiac disorders. Furthermore, as the QF and GWF were increased in the formula, the MC was increased and there was not statistically significant difference in the sample with high content of QF (15%) and GWF (15%) with the control ($P<0.05$). In contrast, the lowest MC and a_w were obtained for the sample with 7.5% QF and 7.5% GWF. The values of MC and a_w were greater than those results from other types of bread which the higher water absorption is related to the replacement of wheat flour with QF and GWF. This behavior has been attributed to the protein microstructure of quinoa protein since the number of pores and nanocavities on the surface of the protein favored the diffusion and adsorption of water into the food matrix and consequently led to higher moisture content (Acosta-Dominguez et al., 2016; López-Alarcón et al., 2019; Puolanne & Halonen, 2010).

Color, due to its importance in commercialization, is another key property which was measured. It is directly influenced by the ingredients constituting the formulation and the baking conditions (Abugoch et al., 2008). Therefore, the color attributes were provided in Table 4. All the samples with QF and GWF exhibited significantly different L* color parameter values as compared to the control. It can be understood that the highest and lowest L^* were obtained for the control (75.56±0.61) and 15% QF and 15% GWF (54.91±0.89), respectively. In the same way, the highest darkening index was observed for the highest QF and GWF can be attributed to the Maillard reaction involving the amino group of the protein or amino acid and the carbonyl group of a single sugar, the amount of protein and starch in the cupcake formula affects the darkening index. As can found from Table 4, the highest protein content was seen for the sample containing 15% QF and 15% GWF and the lowest protein was obtained for the control. Similarly, the maximum fiber (ash content) was observed for the sample with the high QF and GWF. In contrast, the highest and lowest a^* and b^* were obtained for sample containing 15% QF and 15% GWF and the control, respectively. The samples containing QF characterized by the lower range values of the parameter b* (20.05–28.82) that were statistically different ($p<0.05$) from those of the cupcake control (19.50). Similar findings were also reported for the modified quinoa protein isolates which has been used in cupcakes(López-Alarcón et al., 2019). In contrast, the samples with GWF did not show any statistical differences in the b* color parameter (28.22) when compared with the highest QF cupcake. The color difference (ΔE) was also attained for the sample with 15% QF and 15% GWF. Indeed, the cupcakes with QF and GWF showed more color differences (24.65-46.52) in comparison with control, which indicated the samples, presented a greater difference from the control considering the Lab parameters. Since, the values are above $\Delta E>3$consumers may precept the difference by the eye. In all the samples, the total color change was higher when the amount of QF was increased from 1.5 to 15%, and the color parameter exhibited the greatest change was b*.

As compared to the control, the specific volume was lightly increased by adding the quinoa flour. This property should be considered during the cupcake preparation which is a critical parameter for its acceptance by the consumers (Alencar et al., 2015). The specific volume reduction can be related to the volume of the bread depends on the trapping of gas by wheat starch and gluten formation among other factors (Israr et al., 2017). Consequently, wheat flour replacement by quinoa flour can decrease the trapped gas and simultaneously increase water retention capacity of the protein.

The internal porosity of cupcakes as affected by QF-GWF was also provided in Table 4. The lowest porosity was observed for the sample containing the high amount of QF and GWF which clearly showed the effect of protein on the texture. However, the control sample had the 35.92% porosity which was not the highest value and was similar to the sample containing QF or GWF. It could be seen that, by increasing QF, internal porosity of cupcakes was decreased. However, there were little differences in the values of internal porosity between other samples with varying QF and

GWF. The internal porosity values decreased with QF which may be attributed to faster moisture loss from the dough as time of backing proceed.

b) Textural properties of cupcakes

Textural properties of cupcakes at different amounts of QF and GWF are presented in Table 5. In general, the hardness of the samples were increased when the concentration of quinoa flour was increased from 1.5 to 15%, but decreased in the samples with only 15% of GWF which is possibly due to the fact that was insufficient to bind to the added protein. The initial hardness was significantly higher ($p<0.05$) in the samples added with 15% QF-GWF, varying from63.15 N to 65.21 N, whereas the hardness of the samples added with only GWF varied from 35.70 to 55.70 N, and in the samples added with QF, the hardness ranged from 35.22 to 63.18 N. All these values were higher than the hardness of the control sample (33.11 N). It has been reported that the thermal processing extend the amylopectin crystals present in the protein and therefore, swelling of granules and changing in the textural properties was occurred (Patel et al., 2005). Similar to hardness, cohesiveness increased slightly upon increasing the amount of the quinoa flour; the samples added with 15% QF-WG.

GWF (1.09) presented a slightly higher cohesiveness than those added with only QF (1.08) or GWF (1.05). Regarding the elasticity, the samples added with different QF did not show significant differences ($P<0.05$); this indicated that the addition of the QF did not produce a significant effect on the elastic texture of the crumb. In general, the replacement of the wheat flour with QF and QF-GWF did not significantly affect ($P<0.05$) the resilience of the cupcakes (data not provided here); in contrast, the samples in which QF was used showed significantly higher values ($p<0.05$) of resilience as compared to the control; these results suggested that the addition of QF produced cupcakes that required similar energy as the cupcake control for the deformation of their elastic components. Similarly, it has been reported that quinoa protein isolate can increase the strength of cupcakes and need more energy before swallowing (López-Alarcón et al., 2019).

After one month storage, the hardness was higher in the samples added with QF-GWF as compared to that of the samples added only with the QF or GWF and control; bread aging is a complex physical phenomenon that occurs during storage mainly due to the loss or migration of moisture from the crumb. This phenomenon is regularly reflected in the textural properties through an increase in hardness(Fadda et al., 2014).It has been found that the modified quinoa protein isolates had higher water retention capacities than the unmodified counterparts; this could alter the wateradsorption process and the cupcake retrogradation process. With regard to this, it has been reported that some compounds or the physical or chemical modifications of proteins restrict the mobilization of water during storage; this results in a better water retention capacity, which in turn improves the mass and decreases the aging and hardness of the bread (Peng et al., 2017). It was also observed that after 30 days, the cohesiveness and elasticity did not change with respect to the type of flour added; however, these parameters changed with respect to storage time; this suggested that the changes in texture occurred due to the process of retrogradation of starch present in the wheat flour. Therefore, changes in the texture of the cupcakes during storage appeared to be related to the process of replacement of the protein.

c) Sensory evaluation of cupcakes added with QF-GWF

The analysis of textural properties has a high correlation with sensory evaluation(Scheuer et al., 2016). The preference for cupcakes added with QF was significantly higher ($p<0.05$) as compared to that for the control. The samples in which the wheat flour was substituted with the QF had a higher preference ($p<0.05$) as compared to the control; the results indicated that the control was accepted with the score $=2.50$, corresponding to "I like little", whereas in the samples in which wheat flour was replaced by QF-GWF, the scores varied from 4.10 to 4.60, corresponding to "I like very much". Similarly, the ordering test turned out to be congruent with the hedonic scale in a way such that the samples added with QF exhibited greater values of preference. No significant differences ($p>0.05$) were found in the preference and acceptance of the samples added with different level of QF and GWF; this matched with the texture data obtained for the hardness of different samples. It was possibly due to the fact that the force required to compress these cupcakes between teeth was favorable for the preference and the freshness perception of foods(Giannou & Tzia, 2007); consumers reported that the incorporation of QF-GWF into the cupcake produced fresh bread with greater wettability and greater ease in swallowing; however, in the control sample, the consumers reported that the bread was dry and swallowed with greater difficulty; this led to its decreased acceptability.

d) Antifungal activity of cupcakes containing QF

The addition of compounds with high degree of affinity for water could extend cupcake aging during storage. It has been reported that some compounds or additives, such as hydrocolloids, used in baking improve the water retention capacity, texture and shelf life of the final product(Ferrero, 2017). Visual cupcake spoilage by molds and yeasts is the most common reason for the rejection by the consumer. It has been understood that the QF along with GWF delayed the appearance of molds by five and three days, when compared with the case of the control sample stored at 25°C. This effect was greater when the concentration of

the QF was increased. This may be related to the fact that the QF has a more porous surface that is capable of retaining water in its structure in a way such that water is not available for the growth of microorganisms or due to the greater number of protein-carbohydrate interactions in these samples. It has been reported that water and carbohydrates have important effects on the water retention capacity and consequently affect the technological properties and water availability for microorganisms (Poulane et al., 2010). Furthermore, it has been demonstrated that processes, such as freezing-lyophilization, modify the nanostructure of the proteins, improving the absorption and distribution of water molecules(Acosta-Dominguez et al., 2016); this cause slower water mobility with higher viscosity and more polymer-water interactions(Peng et al., 2017), which may result in a decrease in the growth of microorganisms on the cupcakes and an increase in the shelf life of the cupcakes.

IV. Conclusion

The addition of quinoa flour along with germinated wheat flour modifies the physical, textural and sensorial properties of the cupcakes. These changes were directly proportional to the concentration of the added QF and GWF, resulting in better properties when used in the proportion of 15%. The samples in which wheat flour was substituted with QF-GWF presented higher hardness both initially and during storage; the addition of 15%QF-GWF caused greater acceptance and preference on the part of the consumers and delayed the appearance of molds by 15 days, respectively, as compared to the case of the control sample; this indicated that the type of modification and the concentration of the quinoa flour were decisive factors that affected the properties and microbiological stability of the products made using these flours. This research shows that the addition of quinoa flour along with germinated flour leads to sensory and microbiological benefits in cupcakes and extends the shelf life of the cupcakes in which they are incorporated.

Conflict of interest

There are no conflicts of interest to declare.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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Table 1: Ingredients for the cupcake formulation

Flour ratio		Other ingredients*							
QF (g)	GWF (g)	Egg (g)	Sugar (g)	Glucose (g)	Skimmed milk (g)	Sorbitol (g)	Vanilla extract (g)	Yeast extract (g)	Oil (g)
0	15.0	30	22	2.5	3.0	2.0	0.2	0.3	5.0
1.5	10.5	30	22	2.5	3.0	2.0	0.2	0.3	5.0
4.5	7.5	30	22	2.5	3.0	2.0	0.2	0.3	5.0
7.5	4.5	30	22	2.5	3.0	2.0	0.2	0.3	5.0
10.5	1.5	30	22	2.5	3.0	2.0	0.2	0.3	5.0
15.0	0	30	22	2.5	3.0	2.0	0.2	0.3	5.0

**. QF and GWF are Quinoa flour and germinated wheat flour.*

Table 2: Physicochemical properties of quinoa and germinated wheat flour

Parameters (%)	QF	GWF
Moisture	6.78±0.04	3.92±0.03
pH	6.21±0.01	6.27±0.02
Acidity	0.21±0.05	0.31±0.04
Protein	14.78±0.07	11.46±0.06
Gluten	0±0.01	12±0.11
Fat	3.92±0.03	2.30±0.83
Crude fibre	2.45±0.25	2.24±0.67
Ash	2.51±0.02	1.65±0.01
Carbohydrate	69.57±0.89	64.25±0.34

**. QF and GWF are Quinoa flour and germinated wheat flour.*

Table 3: The moisture and water activity of the quinoa flour mixed with the germinated wheat flour during the storage at ambient temperature from 0 to 30 days

QF	GWF	M_c (%)			a_w (%)		
		0**day	15 days	30 days	0 day	15 days	30 days
0	0 (control)	22.17 ± 0.75^{b}	16.27 ± 0.49^{d}	14.27 ± 0.34^{c}	0.68 ± 0.01^{d}	0.67 ± 0.01^{d}	0.66 ± 0.01^{e}
1.5	1.5	17.97 ± 1.01^{e}	15.43 ± 0.45^{e}	13.75 ± 0.49^{d}	0.66 ± 0.01^{e}	0.66 ± 0.01^{d}	0.65 ± 0.01^{e}
4.5	4.5	16.27 ± 0.20^{d}	14.77 ± 0.15^{f}	13.95 ± 0.62^{d}	0.65 ± 0.01^{e}	0.64 ± 0.01^{e}	0.64 ± 0.01^{e}
7.5	7.5	15.70 ± 0.05^{c}	14.63 ± 0.42^{g}	13.14 ± 0.65^{d}	0.66 ± 0.01^{e}	0.60 ± 0.01^{e}	0.58 ± 0.01^{f}
10.5	10.5	22.06 ± 0.16^{b}	20.15 ± 0.29^{c}	15.70 ± 0.21^{b}	0.75 ± 0.01^{c}	0.72 ± 0.01^{c}	0.71 ± 0.01^{d}
15	15	23.78 ± 0.27^{b}	21.22 ± 0.67^{b}	15.65 ± 0.52^{b}	0.76 ± 0.01^{c}	0.74 ± 0.01^{c}	0.73 ± 0.01^{c}
15	0	22.95 ± 1.11^{b}	22.04 ± 1.02^{b}	15.86 ± 0.23^{b}	0.78 ± 0.01^{b}	0.76 ± 0.01^{b}	0.76 ± 0.01^{b}
0	15	25.48 ± 0.08^{a}	24.95 ± 0.11^{a}	17.00 ± 0.57^{a}	0.82 ± 0.01^{a}	0.81 ± 0.01^{a}	0.80 ± 0.01^{a}

** Days in storage.*

Table 4: Nutritional properties and color attributes of cupcake formulated with different amount of QF and GWF.

QF	GWF	Color attributes				Protein, %	Ash, %	Fat, %	Porosity,
		L*	a*	b*	ΔE				
0	0	75.56±0.61[a]	1.25±0.27[f]	19.50±0.41[e]	-	15.75±0.23[d]	1.37±0.05[e]	14.85±0.14[d]	35.92±2.02[c]
1.5	1.5	71.27±0.40[b]	1.39±0.50[f]	20.05±0.12[d]	24.65±0.72[d]	15.92±0.54[d]	1.39±0.07[e]	15.67±0.05[d]	42.94±3.74[a]
4.5	4.5	66.73±0.44[c]	2.75±0.58[e]	21.02±0.78[d]	34.48±0.55[c]	16.62±0.75[c]	1.43±0.11[d]	15.64±0.11[c]	43.14±3.35[a]
7.5	7.5	64.86±0.60[c]	5.14±0.73[d]	23.28±0.24[c]	36.28±0.97[c]	16.97±0.66[c]	1.47±0.21[d]	16.43±0.12[c]	40.96±6.92[b]
10.5	10.5	61.16±0.40[d]	6.23±0.18[c]	25.29±0.86[b]	40.90±1.22[b]	17.15±0.28[b]	1.59±0.08[c]	16.83±0.10[b]	41.18±6.71[b]
15	15	54.91±0.89[e]	9.01±0.84[a]	28.82±0.60[a]	46.52±0.80[a]	18.02±0.68[a]	1.88±0.13[a]	16.60±0.14[a]	29.01±2.34[e]
15	0	65.29±0.48[c]	6.79±0.66[c]	25.46±1.31[b]	33.66±0.44[c]	17.32±0.38[b]	1.64±0.09[b]	15.07±0.05[b]	33.21±4.57[d]
0	15	56.04±0.81[e]	7.52±0.50[b]	28.22±0.44[a]	45.80±0.74[a]	16.62±0.48[c]	1.51±0.10[c]	16.62±0.48[c]	32.79±3.07[d]

Table 5: Textural properties of cupcakes with different amount of QF and GWF

QF	GWF	Hardness, N			Elasticity			Cohesiveness		
		0** day	15 days	30 days	0 day	15 days	30 days	0 day	15 days	30 days
0	0	33.11±0.75[b]	39.17±0.49[d]	39.17±0.34[c]	1.07±0.05[a]	1.07±0.04[a]	1.09±0.03[a]	0.87±0.05[a]	0.97±0.04[a]	1.02±0.03[a]
1.5	1.5	35.22±1.01[e]	35.43±0.45[e]	46.25±0.49[d]	1.10±0.06[a]	1.11±0.06[a]	1.14±0.07[a]	0.85±0.06[a]	0.97±0.06[a]	1.04±0.07[a]
4.5	4.5	38.23±0.20[d]	32.15±0.15[f]	33.11±0.62[d]	1.12±0.05[a]	1.10±0.08[a]	1.13±0.03[a]	1.02±0.05[a]	1.05±0.08[a]	1.07±0.03[a]
7.5	7.5	41.12±0.05[c]	42.15±0.42[g]	45.08±0.65[d]	1.11±0.07[a]	1.12±0.08[a]	1.11±0.02[a]	1.03±0.07[a]	1.04±0.08[a]	1.06±0.02[a]
10.5	10.5	53.17±0.16[b]	57.19±0.29[c]	60.70±0.21[b]	1.13±0.06[a]	1.14±0.05[a]	1.14±0.08[a]	1.08±0.06[a]	1.09±0.05[a]	1.11±0.08[a]
15	15	63.18±0.27[b]	64.21±0.67[b]	65.21±0.52[b]	1.15±0.08[a]	1.15±0.08[a]	1.14±0.09[a]	1.09±0.08[a]	1.11±0.08[a]	1.10±0.09[a]
15	0	56.12±1.11[b]	56.18±1.02[b]	58.18±0.23[b]	1.12±0.05[a]	1.12±0.07[a]	1.12±0.07[a]	1.08±0.05[a]	1.02±0.07[a]	1.11±0.07[a]
0	15	41.12±0.08[a]	42.18±0.11[a]	45.17±0.57[a]	1.13±0.07[a]	1.11±0.09[a]	1.14±0.05[a]	1.05±0.07[a]	1.03±0.09[a]	1.10±0.05[a]

[*] *Days in storage.*

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Refinement in Cultivar of Indian Mustard for Higher Yield Under Thermal Climatic Condition of Uttar Pradesh

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Abstract- The refinement and assessment based field experiment was laid out during Rabi season of 2002 and 2003 on farmers fields at Mainpuri district under National Agricultural Technology Project, Zonal Agricultural Research Station, Mainpuri. The main objective was to find out suitable variety of Indian mustard for sowing in early period under thermal condition and replace the local Indian mustard cultivar '*chhapka'*. The nutrient status of pilot area was low. Five high yielding varieties i.e. *Rohani, Varuna, Kanti, Urvarshi, Pusa Jai Kisan* were tested with local cultivar *Chhapka*. The tested varieties of Indian mustard did not much differ in growth parameters but cv. *Urvarshi* displayed the superiority over all varieties. The lowest seed weight/plant (15.85 /plant) and test weight (4.30 gram) were weighed in local cultivar *Chhapka*, while highest seed weight/plant (18.00 g/plant) and test weight (4.95 gram) were recorded in cv. *Urvarshi*. The highest seed yield of 30.80 q/ha was noted under tested cultivar *Urvarshi* and lowest noted under *Chaapka* (15.70 q/ha). The other tested varieties yielded seed between these two limits. The highest net return of Rs. 99667/ha and BCR (1:3.56) were computed under *Urvarshi* cultivar.

Keywords: *chhapka, fog & frost susceptible, fold, thermal climate, urvarshi.*

GJSFR-D Classification: *FOR Code: 079999*

Strictly as per the compliance and regulations of:

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R. A. Singh [α], I. P. Singh [σ], V. R. Chaudhary [ρ], R. K. Singh [ω] & S. B. Pal [¥]

Abstract- The refinement and assessment based field experiment was laid out during Rabi season of 2002 and 2003 on farmers fields at Mainpuri district under National Agricultural Technology Project, Zonal Agricultural Research Station, Mainpuri. The main objective was to find out suitable variety of Indian mustard for sowing in early period under thermal condition and replace the local Indian mustard cultivar '*chhapka'*. The nutrient status of pilot area was low. Five high yielding varieties i.e. *Rohani, Varuna, Kanti, Urvarshi, Pusa Jai Kisan* were tested with local cultivar *Chhapka*. The tested varieties of Indian mustard did not much differ in growth parameters but cv. *Urvarshi* displayed the superiority over all varieties. The lowest seed weight/plant (15.85 /plant) and test weight (4.30 gram) were weighed in local cultivar *Chhapka*, while highest seed weight/plant (18.00 g/plant) and test weight (4.95 gram) were recorded in cv. *Urvarshi*. The highest seed yield of 30.80 q/ha was noted under tested cultivar *Urvarshi* and lowest noted under *Chaapka* (15.70 q/ha). The other tested varieties yielded seed between these two limits. The highest net return of Rs. 99667/ha and BCR (1:3.56) were computed under *Urvarshi* cultivar. The lowest net return of Rs. 31717/ha and BCR (1:1.81) were computed under local cultivar *Chhapka*. The cultivar *Urvarshi* also increased net income of famers by 3.15 fold, which was higher over other tested varieties.

Keywords: chhapka, fog & frost susceptible, fold, thermal climate, urvarshi.

I. Introduction

The South-Western tract of Uttar Pradesh is famous for cultivation of Indian mustard and has maximum area under cultivation in comparison to other part of U.P. The feedback received from the farmer's fields that the most of farming majority harvest the early planted Indian mustard on available residual moisture of sandy loam, sandy clay loam, light loam and loam sols and save the pre sowing irrigational water. About 1.44 lakh ha cultivation of Indian mustard is popularize with production of 3.55 lakh mt. and 14.00 q/ha productivity under aforementioned situation (Anonymous, 2012), which is about 20.40 per cent in area coverage and 40.06 per cent in production in comparison to total area and production of Indian mustard in Uttar Pradesh (Anonymous, 2020). Majority of farmers grow unreleased cv. Appressed mutant of Indian mustard locally known as "*Chhapka*", which mature in early period over other high yielding cultivars, but it is most susceptible to higher temperature, which harm to germination of seed. This practice of cultivation of Indian mustard reduces the seed yield. Mostly farmers grow the above variety during mid September. The higher temperature during second fortnight of September increase the mordility of germinated plants, therefore, the reduction in seed yield was noted from the farmer's field of this tract of Uttar Pradesh. Therefore, the thermal condition of this tract harm to the plant stand is the major problem for cultivation of early Indian mustard. For the refinement of this problem, the different released varieties of Indian mustard were compared with local variety of *Chhapka*. The suggestion was given to the participants of this study that the assessment will be done by you themselves.

The refinement and assessment of different varieties of Indian mustard is the subject matter of this manuscript.

II. Materials and Methods

The refinement and assessment based field experiment was conducted during autumn season of 2002 and 2003 on 25 farmers fields in Mainpuri district under National Agricultural Technology Project by scientists of Zonal Agricultural Research Station, Mainpuri. The main objective was to find out suitable variety of Indian mustard for sowing in early period and replace the local variety *Chhapka*. The soil of pilot area was sandy loam, having pH 8.2, organic carbon 0.29%, total nitrogen 0.02%, available phosphorus 9.20kg/ha and available potassium 279 kg/ha, thus, the nutrients of experimental area were analyzed low in organic carbon, total nitrogen, available phosphorus and high in available potassium. The pH was determined by Electrometric glass electrode method (Piper, 1950), while organic carbon was determined by Colorimetric method (Datta *et al.,* 1962).Total nitrogen was analyzed by Kjeldahl's method as discussed by Piper (1950). The available phosphorus and potassium were determined by Olsen's method (Olsen *et al*., 1954) and Flame photometric method (Singh, 1971), respectively. Five high yielding cultivars i.e., *Rohani, Varuna, Kanti, Urvarshi, Pusa Jai Kisan* were tested with local cultivar

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Chhapka. All the varieties were sown in the 16 September and harvested at complete maturity. The recommended agronomical practices were followed in raising of Indian mustard cultivars as suggested by Singh and Rathi (1985). The irrigations were given to crop as and when required. The farmers were advocated for the assessment of seed yield but the growth, yield traits and economic study done by scientific team. The yield data was collected from the farmers and statistically analyzed as suggested by Gomez and Gomez (1984).

III. Results and Discussion

The growth, yield traits, seed yield and economic data were statistically analyzed and reported in Table-1 and discussed here under appropriate heads.

a) Effect of early sowing on growth parameters

The different varieties of Indian mustard did not much differ in plant height. The lowest primary branches was counted in local variety of *Chhapka* and other tested varieties displayed at par branches/plant. The insignificant response was recorded in production of siliquae/plant under different cultivars. The similar trend was also noted in weight of siliquae/plant (Table -1). The similar results have also been reported by Singh *et al.* (2019).

b) Effect of early sowing on yield traits

The lowest seed weight/plant was weighed in local cultivar *Chhapka* by 15.85 gram/plant and highest was found in cultivar *Urvarshi* (18.00 g/plant), but insignificant response was found under different tested varieties at early stage sowing. The lowest test weight of 4.30 g was noted under local cultivar *Chhapka*, while highest test weight by 4.95 g was recorded under cv. *Urvarshi*. The other varieties displayed the test weight values under these two limits. These results confirm the finding of Singh *et al*. (2019).

c) Effect of early sowing on seed yield (q/ha)

Results displayed that all the high yielding varieties were found effective in order to increase of seed yield of Indian mustard over local cultivar *Chhapka* (Table-1). The maximum increase in seed yield was recorded in cultivar Urvarshi (15.10 q/ha) closely followed by Rohani (11.65 q/ha) and Pusa Jai Kisan (11.30 q/ha) over local cultivar *Chhapka* under early sowing period. The cultivars *Urbashi* increased the number of siliquae/plant, weight of seed/plant and 1000-seed weight which were responsible for increasing the seed yield of Indian mustard. It is also worthwhile to mention here that the severe density of fog and frost during pod filling stage did not influence to the seed yield of *Urvarshi*. Therefore, cultivar *Urvarshi* proved thermo resistant cultivar and registered higher yield over local *Chhapka* and other improved cultivars. These results are commensurable to the findings of Singh *et al.* (2019)

d) Economic study

The gross return (Rs. 138600/ha), net return (Rs. 99667/ha) and BCR (1:3.56) were recorded higher in cv. *Urvarshi* as compared to other improved cultivars including local *Chhapka*. The lowest gross return (Rs. 70650/ha) net return (Rs. 31717/ha) and BCR (1:1.81) were computed under local variety *Chhapka*. The varietal performance was *Urvarshi* (Rs. 99667/ha) >*Rohani* (Rs. 84142/ha) >*Pusa Jai Kisan* (Rs. 82567/ha) >*Varuna* (Rs. 81442/ha) > *Kanti* (Rs. 80317/ha) and >*Chhapka* (Rs. 31717/ha). The higher and lower seed yield of different varieties were responsible for highest and lowest net income.

The variety *Urvarshi* also increased net income of farmers by 3.15 fold which was higher over other tested varieties.

IV. Conclusion

On the basis of experimental results, the farming community of South-Western and Central tracts of Uttar Pradesh may be advocated for sowing of cultivar *Urvarshi* in early planting period to obtain the higher seed yield, net income and more than three fold net income.

Farmers Reaction

The locality and visiting farmers appreciated the efforts of scientists and they followed the smart agronomy in cultivation of cv. *Urvarshi* of Indian mustard as suggested.

Feed Back

The demand of *Urvarshi* seed increased among farmers due to thermo-resistant, and resistant to fog and frost.

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Table 1: Growth parameters, yield traits, seed yield and economic studies under different treatments (Average data of twenty five participants)

Sl. No.	Variety	Plant height (cm)	Primary branches /plant	Siliquae /plant	Weight of siliquae / plant (g)	Weight of seed/ plant (g)	1000-seed weight	Yield (q/ha)	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	BCR	Net income increase in fold
1.	Rohani	223	13	231	32.34	17.10	4.75	27.35	38933	123075	84142	1:3.16	2.65
2.	Varuna	219	12	229	32.05	17.00	4.76	26.75	38933	120375	81442	1:3.09	2.56
3.	Kanti	217	12	228	31.90	16.90	4.73	26.50	38933	119250	80317	1:3.06	2.53
4.	Urvarshi	220	13	232	32.50	18.00	4.95	30.80	38933	138600	99667	1:3.56	3.15
5.	Pusa Jai Kisan	221	12	220	30.80	16.85	4.71	27.00	38933	121500	82567	1:3.12	3.05
6.	Chhapaka (Local)	185	10	219	30.60	15.85	4.30	15.70	38933	70650	31717	1:1.81	-
	C.D 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	4.14	-	-	-	-	-

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Tips for Writing a Good Quality Science Frontier Research Paper

Techniques for writing a good quality Science Frontier Research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of science frontier then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

The Administration Rules

Administration Rules to Be Strictly Followed before Submitting Your Research Paper to Global Journals Inc.

Please read the following rules and regulations carefully before submitting your research paper to Global Journals Inc. to avoid rejection.

Segment draft and final research paper: You have to strictly follow the template of a research paper, failing which your paper may get rejected. You are expected to write each part of the paper wholly on your own. The peer reviewers need to identify your own perspective of the concepts in your own terms. Please do not extract straight from any other source, and do not rephrase someone else's analysis. Do not allow anyone else to proofread your manuscript.

Written material: You may discuss this with your guides and key sources. Do not copy anyone else's paper, even if this is only imitation, otherwise it will be rejected on the grounds of plagiarism, which is illegal. Various methods to avoid plagiarism are strictly applied by us to every paper, and, if found guilty, you may be blacklisted, which could affect your career adversely. To guard yourself and others from possible illegal use, please do not permit anyone to use or even read your paper and file.

Criterion for Grading a Research Paper (Compilation) by Global Journals

Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals.

Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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